AGRICULTURAL ENGINEERING

Established 1920

This Journal is owned, edited, and published monthly by the American Society of Agricultural Engineers.

Editorial and advertising departments at the executive office of the Society, Saint Joseph, Michigan. Publication office at Benton Harbor, Michigan.

SUBSCRIPTION PRICE: $3.00 a year, plus an extra postage charge to all countries to which the second-class postage rate does not apply; to A.S.A.E. members anywhere, $2.00 a year. Single copies (current), 30 cents each.

POST OFFICE ENTRY: Entered as second-class matter, October 28, 1933, at the post office at Benton Harbor, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921.

CONTENTS FOR MAY 1944

Vol. 25, No. 5

EDITORIAL

Consulting Practice

ESPECIALLY unfortunate at this time is the appearance in the news of alleged abuses under the guise of consulting engineering service. As the tale is told, so-called engineering firms employ men at salaries higher than they could command from industrial concerns under prevailing regulations. Then these men are "farmed out" to industry for fees which yield goodly profits, and the entire bill is charged into cost-plus contracts which eventually must be paid off by posterity.

So far as we know, no agricultural engineers are involved in such charges. And it might be added in passing that, if such abuses actually occur in other circles, it is only the acceptance of an obvious invitation, inherent in the attempt to hold economics in abeyance by edict. What perturbs us is the danger that such accusations, whether true or false, may discourage the development of consulting service in the realm of agricultural engineering.

Professional cards in these pages and notations after the names of A.S.A.E. members in the membership roster have proclaimed the existence of consulting agricultural engineers for many years past. The names have been too few, and the practice too meager. No doubt this has been due in part to sheer inertia of custom, in part to a somewhat sickly estate of agriculture and the industries which serve it. Yet there has been an abiding need for such service, a need which should bloom into opportunity.

Changes already under way in farm methods and equipment, extensive developments impending for the postwar period, an increasing emphasis on fundamental engineering in all such plans and practices, together call for the widest and most efficient application of the limited supply of agricultural engineering talent. Consulting practice is the logical device to serve a goodly part of this need.

Consulting service enables small companies to secure a quality of talent which would be prohibitive on a full-time, permanent basis. The flexibility of consulting service permits either an intensive concentration on a problem for a short time, or continued service on a limited scale. It permits the wide experience of a varied practice to be focussed on a single small assignment.

For larger companies, consulting practice makes possible the services of specialists to a greater degree than otherwise would be feasible. To be sure, there is room for liberalization in the policies of such companies in the utilization of specialized talent in the engineering field; that is, on the consulting basis. We believe they will do well to make more use of consultants, not only as a broad policy, but especially to take full and timely advantage of the rapid advances being made in certain sectors of agricultural engineering technology.

Hoarding Engineers

COMING to light amid the wierd workings of excess profits taxation is the amazing fact that a busy corporation can put an engineer on the payroll at $4,000 a year, yet take only $200 out of the company treasury. It is the obvious outcome of the 95 per cent excess profits tax. To the harassed heads of departments of agricultural engineering in the state colleges, viewing the depletion of their staffs, it seems equally obvious that this expedient is being rather freely followed.

Looking toward the tough postwar problems of reconversion, unemployment of factory personnel, and the prompt development of farm markets to cushion the shock of return to a peace economy, it is well worth while both to industry and to America for a goodly amount of advance engineering to be done. In addition, it is worth something to have engineers on tap, oriented in their jobs, and ready to go ahead with new work, even though there is no great need for their services now. Certainly 5 per cent is a small premium to pay for holding good men in reserve.

All this is good business for industry, possibly for the nation. Far be it from us to belittle the practice of good business, for it is the means whereby America has attained more of the abundant life than any other nation in all history. Just the same, the too-free exercise of this easy expedient amounts to the hoarding of precious man power, much of which might be put to better use during the present emergency.

In particular, we would warn ambitious young members of our profession against being too much flattered by tempting offers. They may well consider that their worth is being appraised, not at $4,000, but at $200. They may only be probationers, engaged only because it costs almost nothing to try them out. We suspect that a considerable part of them will be screened out later, and at a time when new connections will not be so easy to secure.

Bread, Not Stones

BASE would be the gratitude of this republic if it should take at face value the proposals to make farmers out of soldiers and sailors when comes the time for demobilization. Just because they have learned to live in hardship is no reason to sentence them to a lifetime of it. Yet, in most cases, that would be the net result of the land settlement plans being advanced.

After the Mexican and Civil wars there were lush new lands to be brought under the plow, and their settlement by soldiers was feasible. Now there are no such lands. All land good enough (and much not good enough) to return a decent living already is in farms. The acreage now reverted to states and counties because it cannot earn its taxes is proof enough of the futility and the heartbreak of any such program.

The only ways to provide liveable land are to take it from present operators, or to reclaim new areas by costly irrigation, drainage, or possibly clearing. These last are the business of the agricultural engineer, and naturally he would like to do more business. But he knows that too much clearing and drainage have destroyed forests and wild life, created floods and depleted water resources. He knows that irrigation is the problem child in our agriculture. Now he is doing his best to atone for past sins, mostly of ignorant optimists and pork-barrel politicians.

Between wars, when there are veterans to provide for, the problem of agriculture is not bigger production but bigger markets. Creation of the chemurgic movement is proof of that. Irrigation of more land may be preparedness for another war, but it is not solution of the veteran problem. Neither is the other possibility, that of taking land from present operators, on anything like the grand scale contemplated by the visionaries.

To be sure, there are several hundred thousand overage farmers whose retirement has been deferred, and whose operations are due to be taken over by younger men. For most of those farms there is a (Continued on page 192)

AGRICULTURAL ENGINEERING

Vol. 25 MAY 1944 No. 5

Mechanical Harvesting of Cotton Has Arrived

By H. P. Smith

MEMBER A.S.A.E.

HISTORY does not tell us when cotton was first grown for domestic use, but it does tell us that cotton has been harvested by hand from its earliest origin down to the present time. We have no record of any effort being made to pick cotton with mechanical devices before the first patent was granted to Rembert and Prescott in 1850. During the past 94 years more than 800 patents have been granted by the United States Patent Office to inventors on every conceivable principle. The tremendous interest manifested by cotton farmers in mechanical harvesting of cotton will very likely result in renewed efforts on the part of inventors to revive old pickers and to develop new ones. Even with all this effort it can be safely said that at the present time less than five per cent of the world's cotton crop is harvested mechanically. This five per cent is distributed throughout the world.

The Russians have been experimenting with the mechanical harvesting of cotton for many years. They have either bought samples or quantities of all machines developed in this country and shipped them to Russia for extensive trials. These were machines the American cotton grower would not accept. The Russians have even developed mechanical cotton harvesters of their own. Cotton producing countries of South America have either asked for demonstrations or have bought machines for study. Leaders in Australia have investigated the possibilities of mechanical harvesting. A few years ago a Japanese student at the A. & M. College of Texas traveled throughout the cotton belt collecting information, so he said, on cotton harvesting machinery.

The American cotton grower has been offered so many cotton harvesting machines, each of which was represented to be the machine that would revolutionize the cotton industry to such an extent as to change the whole social way of life, that he has grown skeptical of anything that is called a mechanical cotton harvester.

This attitude, however, has changed since the war has created a shortage of man power on the farm. As long as the cotton farmer had ample local or migratory labor available he was not particularly interested in mechanical harvesting. But now that he does not have an abundance of labor for harvesting his crop when, where, and as he likes, he is interested in mechanical cotton harvesters of any type. In fact, he is insisting that sufficient numbers of the best proven and most efficient machines be manufactured so that he may have them to harvest his crop. I have been predicting for the past fifteen years that it would require a shortage of labor and high cost of harvesting to put over mechanical harvesting of cotton. It appears that we now have that situation in the cotton belt and the cotton farmers are anxious to buy any machine that will permit them to harvest a reasonable percentage of their crop. What has the farm machinery industry to offer?

Of the hundreds of patents obtained by inventors less than one-half dozen machines show promise of being manufactured in the near future. These machines fall into two types, namely, the mechanical picker and the stripper.

The most promising of the picker type machines is the one developed by the International Harvester Company. This company has for many years had several engineers whose sole duty was to improve and test their machine under all kinds of conditions in many parts of the cotton belt.

As to the kind of job they have done can best be told by quoting from a report by H. L. Alsmeyer, county agent for Nueces County, Texas, of a demonstration held last September near Robstown, with approximately 1,000 farmers present:

"The International Harvester cotton picker made its initial bow to the general public in south Texas and left cotton-conscious Texans looking at its clean-picked rows, marveling at its speed, efficiency and the fact that it picks a row of cotton clean, leaving only those undeveloped bolls that lower the grade of cotton.

"Humor fell almost as fast as the fluffy white bolls in the machine's hopper. One farmer was heard to remark: 'Picking cotton on Saturday—now isn't that something;' another added 'Picks it clean all right and I haven't noticed it picking any burs off the ground to make it weigh any more'."

The picker is mounted on the rear of a Model H Farmall tractor fitted with a high-clearance attachment. The cotton harvester attachment is mounted as far as possible on a subframe which makes it more easily removable.

The picking unit consists of two drums mounted in staggered positions so that plants are picked first on one side and then on the other. Each drum has 300 rotating, tapered and barbed spindles, which travel rearward in the plants at the same speed the machine travels forward. The spindles are moistened with a thin film of water immediately prior to entering the plants. The moisture aids in picking and insures clean surfaces of the spindles so that they are in condition to do a good job of picking. After the spindles withdraw into the drum through a series of slat bars, they approach a series of revolving rubber disks or doffers, which strip or doff the cotton from the spindles. The doffed cotton is elevated by air into a hopper mounted on and above the tractor. This hopper is dumped by hydraulic power.

The Harvester Company has a smaller picker which is mounted on their Model B Farmall tractor. This unit is attached to the right side of the tractor, opposite the engine, and in front of the transmission and axle housing and the drivewheel. The general principles of design, construction and operation are essentially the same as in the Model H picker attachment.

This paper was presented at a meeting of the Southwest Section of the American Society of Agricultural Engineers at Dallas, Texas, March 10 and 11, 1944.

H. P. SMITH is chief, division of agricultural engineering, Texas Agricultural Experiment Station.

Recently Deere and Company purchased the patent rights of the Berry cotton picker which was patented by H. N. Berry of Greenville, Mississippi. This machine also uses barbed spindles for picking the cotton from the plant. The company has not announced any plans for the future, but they no doubt will carefully study the performance of the machine in its present state of development, make changes if needed, and offer it to the public.

During the past year we saw the revival of the mechanical cotton stripper in the High Plains area of northwest Texas. Strippers used by farmers ranged from newly made sled strippers to two-row, tractor-mounted machines.

Most of the sled strippers were of the two-row finger type. The width of the box was about 80 in, as it covered two rows of plants. Old automobile wheels, binder transport wheels or any kind of wheel about 2 ft in diameter were attached to the box slightly to the rear of the center so that most of the weight was supported and carried on the wheels. The two sets of fingers were welded to a single long bar that extended across the entire width of the box. A lever for raising and lowering the fingers and holding them in a fixed position was attached to one end of the bar. The fingers were made either from square bars, T bars or angle iron having about 1-in legs. When angle iron was used the angles were welded to the crossbar with the valley up. The front end of the angle was drawn together to form a point which was slightly curved upward to prevent the points from digging into the ground. There were about six fingers about 2 ft long spaced approximately 3/4 in apart for each row.

USE OF MECHANICAL COTTON STRIPPER REVIVED

When these sled strippers were used on small plants of stormproof cotton to salvage the last picking, they did a fairly good job. In the operation of a sled stripper, a man rides in the box and uses a rake or wide hoe-like tool to rake the cotton bolls off the fingers back into the box. If the bolls are not raked back, they pile up on the fingers thereby reducing their stripping efficiency.

W. M. Wallace, a blacksmith near Lubbock, Texas, has recently improved the sled stripper by mounting two sets of sled fingers just behind the front wheels, on each side of a row-crop type tractor. Above the fingers is a belt approximately 18 in wide to which are attached several sets of pins. The pins are about 10 in long. The various sets of pins are spaced about 12 in apart on the belt. As the cotton is stripped from the plants by the angle-bar fingers, the pins on the belt drag the cotton back and off the stripper fingers into a cross elevator where it is picked up by air and blown into a trailer drawn behind the tractor.

Some twelve years ago Deere and Company manufactured several hundred single-row, horse-drawn cotton strippers. However, they discontinued making them because during the depression years there was no demand for them, as there was a surplus of farm labor and the price of cotton was low. In 1943 the company designed and built a two-row, tractor-mounted cotton stripper. Field tests in the vicinity of Lubbock, Texas, conducted over a period of several weeks gave satisfactory efficiency and performance. They are offering the farmer the choice between a machine that only strips the cotton from the plant, similar to hand snapping, and a machine that not only strips the cotton off the plant but also extracts the burs as it travels along the row. The company expects to have a number of these machines available for the 1944 cotton harvest.

In 1943 the C. E. Morris Company of Dallas, Texas, manufactured and sold nearly fifty two-row, tractor-mounted cotton strippers to farmers in the High Plains area of Texas. This company is using principles developed by the Texas Agricultural Experiment Station consisting of pickup fingers, two revolving smooth stripping rolls, one of which is under spring tension, and tapered spiral augers to elevate and convey the cotton to the rear of the machine. The pickup fingers and stripping rolls are in alignment with the row of plants. Right and left-hand flight augers convey the cotton from each stripping unit to a central elevator which conveys the cotton up and drops it into a trailer drawn directly behind the tractor.

The efficiency of one of these machines tested in harvesting a hybrid strain of cotton at Lubbock in October 1943 was 96.2 per cent when traveling at 1.8 mph and 93.8 per cent when traveling at 3.4 mph. Farmers using the machines usually operated at the higher speed.

In early December, 1943, I visited the Pinkert farm, near Slaton, Texas, where a two-row, tractor-mounted cotton stripper was being used to harvest cotton yielding about 3/4 bale per acre. A brother and sister, both under twenty years of age, had actually harvested six bales of cotton in seven hours. This crew of two estimated they could, under favorable conditions and traveling at approximately 3½ mph, harvest eight to ten bales of cotton a day.

Assuming that the average two-row, tractor-mounted cotton stripper harvested 6 bales of cotton a day, and figuring tractor costs at 60c per hour, tractor operator and helper at $6.00 per day, depreciation and necessary repair charges at $8.00 per day, the total cost would be $18.80 per day, or $3.13 per bale. The average price for snapping 2,000 lb of cotton last year was $1.50 per hundred ($30.00 per bale), or $180.00 for the six bales. This leaves a net saving, when the machine is used, of $26.87 per bale, or $161.20 per day.

Years of experimental tests have shown that the efficiency of any type of mechanical cotton harvester depends to a large extent on cotton varietal characteristics. Many well-designed cotton harvesting machines have no doubt failed largely because of the lack of adaptable plant characteristics. We have found that the efficiency of the stripper type machine will vary as much as 17 per cent between varieties which were grown on adjacent rows in the same field. We have repeatedly said that anyone planning on using a mechanical cotton harvester should select a variety having characteristics suitable for machine harvesting.

Our idea of a suitable plant type is one having relatively short fruiting branches, no long vegetative branches, light foliage, storm resistance, and large bolls that spread open enough to permit extracting or picking and are borne singly on peduncles (boll stems) that snap easily with the stripper yet do not break readily when a picker is used.

The development of a highly stormproof type of cotton (called macha) in the High Plains area is playing an important part in the efficient use of the stripper type machines in northwest Texas. It is estimated that 175,000 acres of this type of cotton was grown in that area in 1943. This acreage will likely be doubled in 1944 as all farmers who expect to use the stripper type machine are planning to plant a stormproof type of cotton. New types of cotton more suitable to the picker machine are being rapidly increased.

SEPARATION OF LEAF PARTICLES FROM SEED COTTON

The statement was made in Texas Station Bulletin No. 580, entitled "Mechanical Harvesting of Cotton as Affected by Varietal Characteristics and Other Factors", that "one of the major problems of mechanical harvesting of cotton is the separation and removal of green-leaf trash from the harvested cotton between the time it is taken from the plant and before it reaches the storage bag or trailer." The elimination of green leaf and moisture holding vegetative matter in mechanically harvested cotton is still one of the foremost problems in the mechanical harvesting of cotton. A very small amount of green and moist vegetative material mixed with harvested seed cotton will cause it to sweat, heat and mold, resulting in lower grades and poor quality cotton.

No mechanical devices have been developed that will separate all sizes of green-leaf particles from seed cotton, but there is some promise of solving the problem by removal of the leaves from the plant by means of chemical treatment before harvesting with the machine. At least three large commercial concerns are working on this problem.

A fast-acting chemical will not only kill the leaves on cotton plants but will also cause them to "freeze" on the plant, while a slow-acting chemical appears to cause the leaf to shed from the plants. The problem, therefore, appears to be to find a chemical that will slowly kill the leaves and that at the same time can be applied easily and cheaply. I have high hopes that the problem will be solved in the near future.

In the January, 1943, issue of "Textile World," the statement was made: "No spinning tests are available on machine-picked cotton. So for all practical purposes the mechanical picker cannot be universally accepted until such tests are made and until they meet the spinners requirements."

The cotton spinning laboratories of the U. S. Department of Agriculture have made some limited tests on cotton that was hand-picked and machine harvested in 1942 and 1943. These tests, however, were made as service tests (Continued on page 172)

Seasonal Loading and Freezing Rates of Domestic Frozen Food Cabinets

By John E. Nicholas and Gilma Olson

MEMBER A.S.A.E.

STUDIES carried out at the Pennsylvania Agricultural Experiment Station during the past three years (1941-43) corroborate numerous findings previously reported in a paper, entitled "Performance of Domestic Frozen Food Cabinets," in AGRICULTURAL ENGINEERING for July 1942 (vol. 23, no. 7).

Such units have been constructed in many different designs and sizes, but only the well type in capacities of 15 and 17 cu ft was available for these studies.

Since the ultimate user of any piece of equipment is its final judge, housewives were included as collaborators and critics in these experiments. Four were selected. This work served to train them in methods of handling, processing, and wrapping foods for freezing, and it provided a reasonable indication as to when and how much one person can prepare of various fruits and vegetables during a single growing season. It also provided time-study facilities on time requirements in preparing different products for freezing.

Records of dates when homegrown products were frozen resulted in the production timetable for the family shown in Table 1. Peaches and sour cherries were purchased from the orchards of Pennsylvania State College at the time of picking; the other products were homegrown except asparagus which was bought from the local vegetable store but delivered at the time of cutting. Table 1 does not represent all the fruits and vegetables this family of six required during the year but merely the portion of frozen food shared with others in this experiment.

Total food products frozen and stored in the 15-cu-ft box amounted to 220 qt and 125 pt weighing approximately 406 lb, which occupied roughly 11.25 cu ft, or 75 per cent of the usable freezer and storage volume. Its average operating cost was 125 kw-hr per month based on a year's performance. This included all freezing operations and other incidental losses incurred during placing, shifting, and removing packages.

Fig. 1 shows the three-compartment, 17-cu-ft cabinet with the temperature measuring equipment located on a table in front of it.

Measurements of packages in the frozen state showed that on the average a pint package occupies 40.5 cu in, while a quart requires 65.5 cu in. These figures varied with the tightness of packing.

Fig. 2 illustrates some of the types of packages used in the experiment: the cubes are plastic covered; the brick-shaped containers are inner-lined with cellophane bags; and the similarly shaped, paraffin-coated containers are equally inner-lined.

Every package was weighed before and after freezing. A few showed slight damage or were partially open because of handling during storage. Loss in weight of nearly 20 per cent was found only in one package. This loss may have occurred before freezing, either because the container was improperly sealed or because of a tear in it. Properly sealed packages were in good condition. Some showed no loss in weight, a few a loss in excess of 1 per cent, and others were found to have gained in weight from less than to slightly more than 1 per cent. Frost on the outside of the package from plates or coils during storage or spillage from other packages accounted for the gains.

Preparation for Freezing. The housewives prepared the homegrown fruits and vegetables in the same careful manner as for table use. The fruits were put up in syrup or in sugar depending on each family's taste. The vegetables were blanched from 3 to 4 min in boiling water, cooled, packed, and sealed.

Cellophane inner-liners as well as the wax plastic containers were sealed with a hot flatiron.

TABLE 1. FROZEN FOODS PRODUCTION TIMETABLE FOR ONE OF THE EXPERIMENTAL FAMILIES IN 1942

Date	Product	Size, qt	Size, pt	Weight, lb	Dry	Syrup
May, 1942	Asparagus	7		8.11	7	
May, 1942	Asparagus		14	9.33	14	
May, 1942	Rhubarb	2		2.65	2	
May, 1942	Rhubarb		1	.68	1	
June, 1942	Strawberries	8		11.66		8
June, 1942	Strawberries		10	9.31		10
June, 1942	Peas	1		1.22	1	
June, 1942	Peas		5	3.47	5	
June and July, 1942	Sour cherries	17		34.08		17
July, 1942	Raspberries	12		22.00		12
July, 1942	Raspberries		2	2.02		2
July, 1942	String beans	19		21.35	19	
August, 1942	Golden Bantam corn	4		5.39	4	
August, 1942	Golden Bantam corn	4	8	6.74	8	
August, 1942	Baby lima beans		8	5.88	8	
August, 1942	Fordhook limas	1		.96	1	
August, 1942	Fordhook limas		4	2.95	4	
August, 1942	Pole limas	1		1.20	1	
August, 1942	Pole limas		10	7.13	10	
August, 1942	Peaches	20		37.41		20
October, 1942	Cauliflower	7		6.66	7	
October, 1942	Cauliflower		4	2.95	4	
	Total	99	66	203.15		

Preparation Time from Garden to Freezer. On May 18 (shown in Table 1 only as May), 18 of the 21 packages of asparagus were put up. Sixteen pounds of freshly cut asparagus, which were delivered at 10:30 a.m. were washed, cut, blanched, and sealed into 12 pint and 6 quart packages between 12:00 noon and 2:00 p.m.

This paper was presented at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1943, as a contribution of the Rural Electric Division.

Authorized for publication, February 19, 1944, as Paper No. 1221 in the Journal Series of the Pennsylvania Agricultural Experiment Station.

JOHN E. NICHOLAS is professor of agricultural engineering and GILMA OLSON is assistant professor of home economics, Pennsylvania State College.

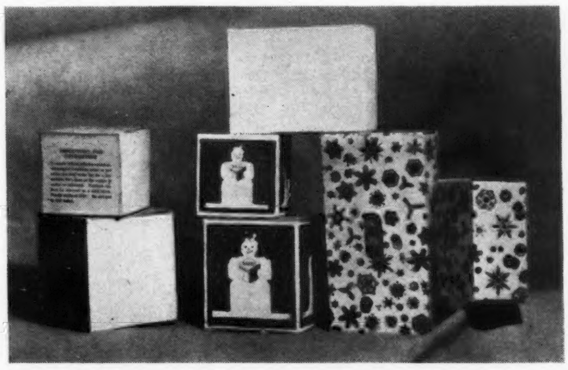


Fig. 1 (Left) Domestic type, three-compartment freezer cabinet. Capacity, 17 cu ft. Two storage compartments separated by a baffle and a 2.7-cu-ft freezer compartment. Below it is the condensing unit operated by a ⅓-hp motor. On the table are thermocouples, potentiometer, and accessories used in measuring the rate of freezing • Fig. 2 (Right) Types of vegetable and fruit packages used in the experiment

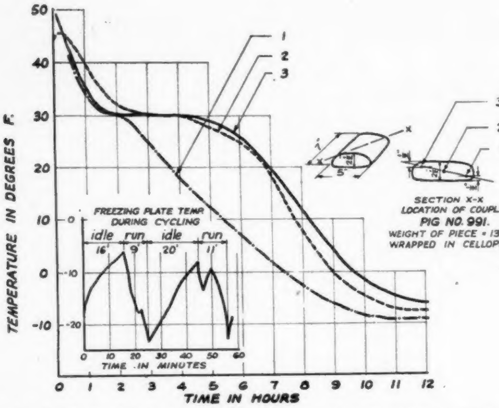


Fig. 3 Rate of freezing of pork shoulder, 2½ in thick, weighing nearly 3.1 lb, on freezer plate without air motion, in a domestic type cabinet. Freezer plate temperature during cycling, lower left.

with two people working. The packages were weighed and put in to freeze at 2:30 p.m. The time between cutting and freezing was about five hours. The 16 lb of freshly cut asparagus, the largest number of packages put up in one day, gave 13.3 lb of edible product.

The 20 packages of peaches (August) were put up on two different days. Eleven quarts were blanched for peeling, cut and sealed in one hour's time. Five or six peaches were scalded at a time, cooled, peeled, then placed directly into the syrup of a container, and immediately sealed. This proved to be a very efficient and satisfactory procedure. The time requirements per quart prepared were longer for string beans than any of the fruits or other vegetables. Frozen beans were most satisfactory if picked several days before their prime.

Rate of Freezing of Pork. It has been stated and generally accepted that the quicker a product is frozen the better its quality. It also is common belief that the lower the temperature which a product finally attains in the freezer cabinet, the longer it can be safely stored. Storing at zero to 10 below is common practice.

Figs. 3 and 4 show the time required to freeze family-size pork shoulders weighing 3 to 3¾ lb without air motion on the freezer plate of a domestic type cabinet. The lower left corner of Fig. 3 illustrates the freezer plate temperatures and the time of cycling of the unit which was under thermostatic control during the freezing experiment. Curves 1, 2, and 3 show the rates of freezing at different locations in the pork on same vertical plane, section X-X. Curve 2 represents temperatures taken near the center, while curve 1 represents temperature about ½ in from freezer plate.

The temperature range between 31 and 25 F (degrees Fahrenheit) is regarded as the "zone of freezing", sometimes called the "zone of crystal formation".

Fig. 5 shows the rate of freezing with air motion of nearly equal weights of pork shoulders in a locker plant freezing room operating at –10 to –20 F. The time required to freeze the centers of both pieces differed but slightly. Piece (b) was wrapped in brown paper paraffined on one side; piece (a) was wrapped in cellophane.

Fig. 3 shows that a 2½-in-thick piece was frozen at the end of the sixth hour, while Fig. 4 shows that a 3½-in-thick piece required over 9 hr. Freezing with colder air in motion is illustrated in Fig. 5, but the advantage of air motion is not as pronounced as might be expected.

Experimental Fruits and Vegetables. Between July 7 and October 6, 1943, five graduate students* in home economics prepared and froze the following number of packages of each product: strawberries 14, green beans 111, red and yellow plums 5, cut corn 48, cantaloupes 16, lima beans 23, spinach 18, grapes 21, broccoli 16, brussel sprouts 6, hubbard squash 6, and 14 ears of corn.

*The authors wish to express their appreciation for the assistance of the following graduate students in the Department of Home Economics at The Pennsylvania State College: Eleanor Gleed, Gertrude Simpson, Mary Lane, Mary Benbow and Celeste Burgeson. Figs. 6 to 9, inclusive, represent part of the work done by Eleanor Gleed to meet thesis requirements.

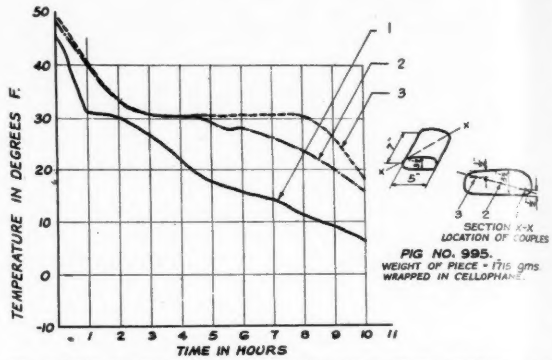


Fig. 4 Rate of freezing of pork shoulder, 3½ in thick, weighing nearly 3.8 lb on freezer plate of domestic type freezer without air motion. The three points in the meat were in the same plane cut on section X-X

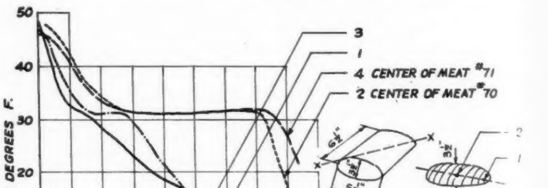


Fig. 5 Rate of freezing of pork shoulder weighing 3.6 and 3.4 lb on freezer coils with air motion in locker plant freezer room operating between -10 and -20 F

The fruits were put up in various ways: whole dry, whole with sugar, crushed without and with sugar or syrup. Vegetables like string beans were French cut (the long way) or cross cut (the short way) then steamed or scalded in hot water for intervals of 3, 5, 10, and 15 min. Vegetable packages were put up dry or in brine using 2 teaspoonsful of salt to a quart of water. Corn on the cob was also blanched in the different ways indicated. Cut corn was blanced on the cob, cooled under a faucet of cold running water, then cut off the cob and packed for freezing.

Rate of Freezing Fruits and Vegetables. To measure the rates of freezing of all types of packages, thermocouples made with No. 30 copper-constantan, enamel-covered wires were used. The assembly of all instruments is shown in Fig. 2. Measurements of temperatures were made by inserting thermocouples in pieces of fruit or vegetable which were then placed in the approximate geometric centers of the packages.

Rates of freezing of cantaloupe balls, string beans, lima beans, and broccoli flowers are shown in Figs. 6, 7, 8, and 9. The six curves represent the temperatures at the approximate centers of the six different packages as indicated. In all cases, as was expected, the extra load of a brine pack required longer to freeze. After freezing the packages attained nearly uniform temperatures of zero or a few degrees below. This is illustrated in Fig. 10 which also shows the cycling time and the freezer plate temperatures. In Fig. 10, couples 4 and 5 are temperatures of two different packages, varying less than one degree, maintained below 0 F.

Under similar conditions a thin package, as may reasonably be expected, freezes quicker than a thick one. This is illustrated in Figs. 3 and 4. With an inch difference in thickness, the time required to reach 25 F was 6 and 9 hr for thin and thick packages, respectively.

Packages do not freeze uniformly throughout. The portion nearest the plate freezes first, and the graduation in temperature is from the plate through the center toward the top, as shown by curves 1, 2, and 3 in Figs. 3 and 4, also curves 1 and 2 in Fig. 5(a) and curves 3 and 4 in Fig. 5(b).

TABLE 2. WEIGHT, SIZES, SHAPES OF FRUIT AND VEGETABLE (Figs. 6, 7, 8, and 9) PACKAGES AND THEIR CONTENTS AS THESE MAY AFFECT THE SPEED OF FREEZING

Figure	Curve No.	Package No.	Package Weight, g	Fruit or vegetable weight, g	Weight of brine, sugar or syrup, g	Total weight package, g	Package Size	Package Shape	Outside surface, sq in
6*	1	119	33	248	0	281	pt	cube	63.4
6†	2	120	18	248	0	266	pt	brick	62.4
6	3	121	34	248	50	332	pt	cube	63.4
6	4	122	18	248	50	316	pt	brick	62.4
6	5	123	34	248	160	160	pt	cube	63.4
6	6	124	18	248	160	426	pt	brick	62.4
7	1	145	33	198	0	231	pt	cube	63.4
7‡	2	146	28	198	0	226	pt	brick	66.1
7	3	147	33	198	204	435	pt	cube	63.4
7	4	148	29	198	204	431	pt	brick	66.1
7	4	148	29	198	204	431	pt	brick	66.1
7	5	149	28	198	0	226	pt	brick	66.1
7	6	150	28	198	204	430	pt	brick	66.1
8	1	168	31	250	0	281	pt	cube	62.4
8	2	169	30	250	170	450	pt	cube	62.4
8	3	170	26	250	0	276	pt	brick	66.1
8	4	171	26	250	170	446	pt	brick	66.1
8	5	172	31	250	0	281	pt	cube	63.4
8	6	173	31	250	170	451	pt	cube	63.4
9	1	219	27	135	0	162	pt	brick	66.1
9	2	220	27	135	286	448	pt	brick	66.1
9	3	221	32	135	0	167	pt	cube	63.4
9	4	222	31	135	286	452	pt	cube	63.4
9	5	223	32	135	0	167	pt	cube	63.4
9	6	224	31	135	286	452	pt	cube	63.4

*Square inches of surface resting on freezer plate = 10.4
†Square inches of surface resting on freezer plate = 15.5
‡Square inches of surface resting on freezer plate = 23.2

If rapidity of freezing is important and desirable, thickness of package should be held to a minimum, a condition which will provide a larger surface on the freezer plate in proportion to the weight of each package. The packages in commonest use in storing fruits and vegetables in the frozen state have been developed to provide ease of packing and to conserve storage space.

Table 2 gives the weight of some of the experimental containers and their contents. Their rate of freezing is illustrated in Figs. 6, 7, 8, and 9. All six packages shown in each figure contained equal weights of product to be frozen, differing only in amounts of sugar, syrup or brine. Freezing rate of each package is represented by a temperature curve taken at its center. In Fig. 6, couples 1, 2, 3, and 4 show rate of freezing of dry packs while curves 5 and 6 show those of brine packs.

In nearly all cases it required 1½ hr of cooling before freezing started. With brine or sugar packs the time required to go through the zone of crystal formation was 3 to 4 hr longer. This is most clearly illustrated by curves 1, 3, and 5 as compared to curves 2, 4, and 6 in Fig. 9. It appears that brines and syrups retard the rate of freezing and add to the load of the cabinet compressor; hence they increase the cost of freezer unit operation. Unless brines add to the quality of a product, they appear to have no advantage. Experimentation might logically be continued on this subject.

Within the limits of this investigation no particular shape of package showed pronounced advantages or disadvantages.

Basing the results of this experiment on the eating quality of the food products stored as they were affected by the rate of freezing, no outstanding differences could be determined by taste, appearance or color.

The rate of freezing of meats, fruits and vegetables in the domestic type cabinet is as rapid[1†] as is obtainable in locker or individual farm freezers. The results of experiments by DuBois and Tressler with frozen poultry[2] indicated that it was difficult to note by casual examination the difference between chickens frozen rapidly and those frozen more slowly. There were, however, noticeable differences in the microscopic appearance of the muscle tissue of chickens frozen at different rates; however, all of the roasted chickens were of good quality and there was no easily discernible difference in flavor, aroma or texture between two rates of freezing.

Not all the fruits and vegetables frozen in these experiments were scored for palatability, but scoring carried out on string beans, corn, lima beans and some fruits showed that all were palatable and satisfactory for table use. Corn on the cob was, however, considered less palatable than cut corn.

The temperature of the frozen package, if it remained on the freezer plate, varied about one degree, Fig. 10. A larger temperature difference was found at different levels in the storage com-

†Superscript numbers indicate references appended to this paper.

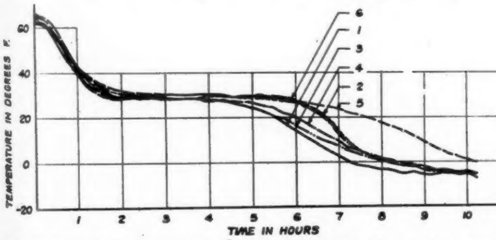


Fig. 6 Rate of freezing cantaloupe balls packed dry, in dry sugar, and in brine — in cube and brick-shaped pint packages. Thermocouples (in center of package in each case): (1) No. 119 (cube) dry pack; (2) No. 120 (brick) dry pack; (3) No. 121 (cube) dry sugar pack; (4) No. 122 (brick) dry sugar pack; (5) No. 123 (cube) brine pack; (6) No. 124 (brick) brine pack

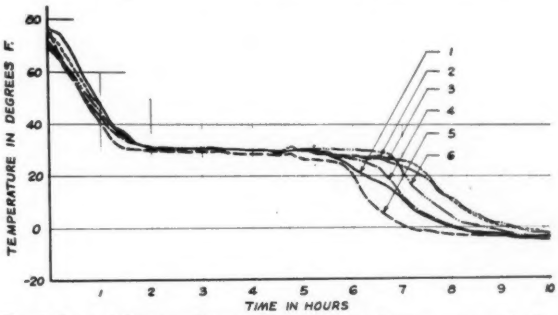


Fig. 7 Rate of freezing string beans in pint packages — cross cut, dry in brine, and French cut, dry in brine. Thermocouples (in center of package in each case): (1) No. 145 (cube) cross cut, dry pack; (2) No. 146 (brick) cross cut, dry pack; (3) No. 147 (cube) cross cut, brine pack; (4) No. 148 (brick) cross cut, brine pack; (5) No. 149 (brick) French cut, dry pack; (6) No. 150 (brick) French cut, brine pack

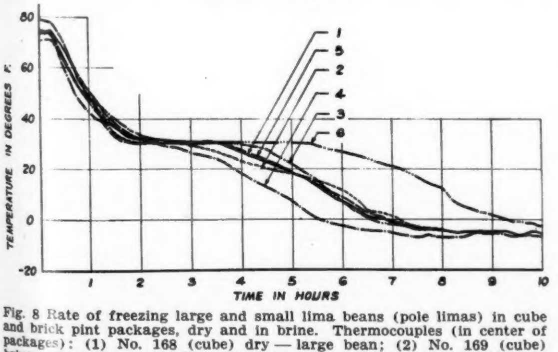


Fig. 8 Rate of freezing large and small lima beans (pole limas) in cube and brick pint packages, dry and in brine. Thermocouples (in center of packages): (1) No. 168 (cube) dry — large bean; (2) No. 169 (cube) brine — large bean; (3) No. 170 (brick) dry — large bean; (4) No. 171 (brick) brine — large bean; (5) No. 172 (cube) dry — small bean; (6) No. 173 (cube) brine — small bean

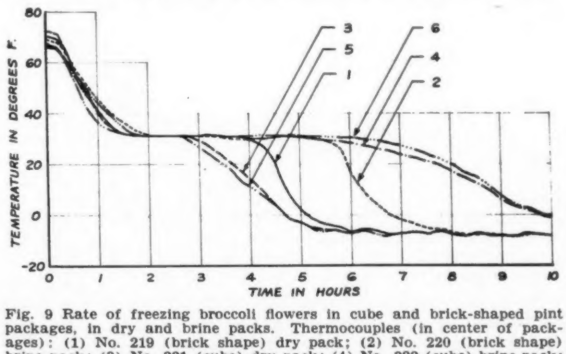


Fig. 9 Rate of freezing broccoli flowers in cube and brick-shaped pint packages, in dry and brine packs. Thermocouples (in center of packages): (1) No. 219 (brick shape) dry pack; (2) No. 220 (brick shape) brine pack; (3) No. 221 (cube) dry pack; (4) No. 222 (cube) brine pack; (5) No. 223 (cube) dry pack; (6) No. 224 (cube) brine pack

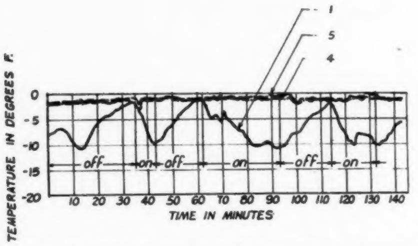


Fig. 10 The time of cycling and variation in plate temperature between "on" and "off". Thermocouples: (1) Plate temperature; (4) and (5) quart cube-shaped containers, contents of which had been frozen the previous day

partments, if packages were piled to lid level, but the temperature of packages at the same levels were nearly the same.

Experimental results recently reported[3], that fluctuations in storage temperatures do not affect the quality of the product if the storage temperature is 5 F or less, are significant and suggest the possibility of a satisfactory one-compartment frozen storage unit. A freezer plate or freezer space seems important, however, when all variables are taken into account.

An accepted standard seems necessary to be used as a basis upon which quality of processed food may be compared. All fruits and vegetables which were frozen were found palatable after freezing.

Of all methods of storing it is accepted that frozen foods lose the smallest percentage of their original vitamin contents; studies, however, should be carried out on all related factors which may be affected by (a) rate of freezing, (b) temperature of storage, and (c) length of storage.

The four experimental families during 1942 and 1943 used no frozen packages during the months of June, July, August and September. In most cases few packages were used in the month of October, indicating that families rely on garden or fresh fruits and vegetables during the summer months. The length of storage period seems to be 8 months.

Testing Foods for Palatability. Tests were made by graduate students in home economics of a few of the samples of frozen foods. Additional tests are yet to be made.

There was no appreciable difference in the palatability of the vegetables that were steamed and those that were blanched.

Vegetables put up in brine were not found superior to those put up dry. Method of pack seemed to make little difference.

Green beans when frenched and packed dry were more palatable. Lima beans were graded as to size. The size of the bean made a greater difference than the method of pack. Corn cut from the cob scored higher that that frozen on the cob. The latter had a characteristic "hay" flavor. Cantaloupe balls packed in a 40 per cent sugar syrup were superior to those packed in brine or packed dry, but did not have a fresh cantaloupe flavor.

SUMMARY

1 This paper reports results of three years of investigation of the domestic type freezer cabinets.

2 Two "well" type units, one of 15 and the other of 17-cu-ft capacity, were used in these experiments. The smaller unit consumed an average of 125 kw-hr of electric energy per month, a maximum of 75 per cent of its freezer and storage volume being used during that year. Other operating costs were trifling, although a moderate expense was involved in preparing and packaging foods for freezing.

3 Commercial containers of cube and brick shapes were used for fruits and vegetables. Meats were wrapped in cellophane and brown paper. An average pint occupied 40.5 cu in and an average quart 65.5 cu in, with considerable variation with tightness of packing.

4 In general, the thinner the package the faster the freezing process occurred. This may be of importance if rapidity of freezing is necessary. No noticeable deterioration of food was observed during these tests.

5 Freezing of food occurred with lessened rapidity from the freezer plate upward through the packages.

6 String beans were considered the most variable product to freeze, primarily because not everyone will pick them in their "proper prime" for freezing process. These should generally be picked while still very tender to be reasonably satisfactory in the frozen state.

7 Fruits or vegetables frozen in any shaped package, either quart or pint, require on the average 1¼ to 2½ hr to be brought to the freezing temperature and from 3 to 5 hr to freeze, which is generally between 28 and 31 F, depending upon the contents of the package and the consistency of the brine or syrup. After the package freezes at the above temperatures, an additional time of 2 to 5 hr is required to subcool the temperature of the frozen material to subzero temperatures, at which the packages are maintained in the frozen state.

REFERENCE

1 "Farm Freezer Analysis"—C. W. DuBois, AGRICULTURAL ENGINEERING, vol. 24, no. 10, October, 1943.

2 "The Effect of the Rate of Freezing and Temperature of Storage on the Quality of Frozen Poultry"—C. W. DuBois and D. K. Kessler, Refrigerating Engineering, vol. 44, no. 2, August, 1942.

3 "The Effect of Fluctuating Storage Temperatures on Frozen Foods and Vegetables" — A. Hustrulid and J. D. Winter, AGRICULTURAL ENGINEERING, vol. 24, no. 12, December, 1943.

Mechanical Harvesting of Cotton

(Continued from page 168)

on a fee basis for private concerns and are not available for release by the Department.

In 1943 the Texas Agricultural Experiment Station and the U. S. Department of Agriculture began a cooperative study on the spinning qualities of three varieties of cotton differing widely in their staple qualities as affected by different methods of harvesting, namely, handpicking, handsnapping, and machine stripping. The Texas station grew and harvested the three varieties of cotton—Hibred, Deltapine 14, and Coker's Wild 15 — at both College Station and Lubbock. After the cotton was harvested by the three methods and the snapped and stripped cotton was run through the station bur extractor, it was shipped to the U. S. Cotton Ginning Laboratory at Stoneville, Mississippi, where it was cleaned and ginned. The cotton was then shipped to the U. S. Cotton Spinning Laboratory at College Station where it was run through regular commercial mill cleaning machines to remove and determine the amount of dirt, trash, and waste in the cotton, after which it was spun into yarn. The yarn was then tested for strength and appearance.

The results of this study show that there was no difference in the spinning quality and appearance of the yarn as affected by method of harvesting for either of the three varieties. There was practically no difference in the amount of waste removed from the short-staple Hibred variety for any method of harvesting. With the longer staple Deltapine 14 and Coker's Wild 15 the amount of waste removed from the handsnapped and machine-stripped cotton was significantly more than that removed from the handpicked cotton. There was little difference in the waste removed from the snapped and the machine-stripped cotton for the two varieties. There was no significant difference in the strength and appearance of the yarn between the three methods of harvesting for the three varieties.

To summarize, it appears that the cotton farmer needs and wants mechanical cotton harvesters; that machines are developed and ready to be manufactured; that suitable varieties for machine harvesting are available; and that the green-leaf problem is being solved.

Be Accurate

BE extremely careful of the accuracy of your statements. This seems almost trite, and yet many engineers lose the confidence of their superiors and associates by habitually guessing when they do not know the answer to a direct question. It is certainly important to be able to answer questions concerning your responsibilities, but a wrong answer is worse than no answer. If you do not know, say so, but also say, "I'll find out right away." If you are not certain, indicate the exact degree of certainty or approximation upon which your answer is based. A reputation for dependability and reliability can be one of your most valuable assets.

This applies, of course, to written matter, calculations, etc., as well as to oral reports. It is definitely bad business to submit a report to the boss for approval without first carefully checking it yourself, and yet formal reports are sometimes turned in full of glaring errors and omissions.—

W. J. King in "Mechanical Engineering," for May, 1944.

Integrating Farm Machinery with the Tractor

By Harold E. Pinches
MEMBER A.S.A.E.

LOOKING backward at the development of farm machinery, it is apparent that the tractor was developed first as a "tractor", that is, a pulling machine, or iron horse. Turning to the future possibilities of adapting farm machinery to the tractor, we should keep in mind this "iron horse" concept on which much of our farm machinery grew up. A brief review of changes and developments which are well known, may bring out some of the possibilities for further advances.

For the early tractors, there was only horse-drawn equipment to hitch them to. It did not take long to find out that machines had to be built stronger and in some respects built differently for operation with tractors. But these first machines were all trailer type implements hitched to the tractor by means of a drawbar.

Another early use of the tractor, but one which did not greatly change its form or require change, was the use of the tractor as a source of belt power to run stationary machines such as threshers.

An important step forward was made when implements were mounted on the tractor. Of course, the mounting of the cultivator was the first outstanding accomplishment in this direction. The mounted cultivator pointed the way to horseless farming. Also, it demonstrated two important principles. First, it showed that the tractor could carry its complementary equipment. Second, it brought out the fact that equipment could be integrated with the tractor and in turn the tractor could be integrated with the equipment.

The trend today is toward more and more tractor mounting, more and more integration of equipment with the tractor. For example, a self-propelled combine is a step toward a tractor-integrated combine. We can fairly assume that the self-propelled combine is a step toward mounting the combine on a tractor, or otherwise integrating tractor and combine so that the tractor is the motive power for the combine, and probably the power for operating the combine too, instead of having a built-in power unit for propulsion which is not in use except when this specialized equipment is used as a combine.

There may be a place for a specialized, self-propelled combine on large farms where it can be used on large enough acreage. This is true of all specialized equipment. However, there are many, many times as many smaller farms which cannot justify a self-propelled combine. The development which would seem probable is some type of tractor-integrated harvesting equipment that will have the same flexibility of operation that the self-propelled combine can offer, but which will permit charging off the costs of the power and transporting components against a variety of operations.

The power take-off widened the field of implements operated by the tractor. It also permits taking crop-processing machines, such as the forage harvester, to the field, thereby eliminating the arduous work of bringing heavy crops of green hay and corn silage to the processing machinery at the barn.

But these machines are probably in a transitional stage. They are still trailer type, self-transporting, with power required both for propulsion and for operation—power brought to them from the outside by a shaft from the tractor. So long as we have the power take-off, it is desirable to have A.S.A.E. standards on power take-off speeds, direction of rotation of the shaft, height of shaft above the ground, etc. However, the forage harvester and other equally large machines pulled behind the tractor and with a wagon pulled beside or behind that are at best cumbersome and ill-assorted combinations, which we can hardly look upon as finished jobs of development of farm machinery.

Let us look now at the tractor itself for a clue or a guide as to what may be possible in adapting farm machinery to the tractor. The tractor can do at least all of these things:

1 It can carry, or at least partially support, all of the implements which work with it, instead of merely pulling them. This permits elimination of wheels and framework necessary with non-integrated equipment.

2 It can steer the implements, both for gross movements of the whole implement, and also, if necessary, for differential steering of parts of an implement.

3 Perhaps the most important of all, it can supply power in numerous forms.

The tractor can *pull,* either directly or by means of a cable and winch. The tractor can *push,* through a push-bar or some other apparatus on the front of the tractor. It can *lift,* by means of a cable over a pulley, or by arms actuated by one or more power cylinders. It can provide power in *rotary* form either by a belt or a power take-off. It can supply power by several means of *flexible* transmission which include a flexible shaft, that is, a completely flexible shaft distinguished from the jointed shaft of the power take-off. This flexible transmission of power can also be done by *hydraulic* means, by *pneumatic* means, or by means of an *electric* current, that is, an electric current generated on the tractor and transmitted for use through electrical apparatus on the equipment. Finally, we might mention the possibility for the future of *electronic* transmission of power.

These numerous forms in which power can be supplied by the tractor are only beginning to be exploited. Many possibilities have not been fully explored.

We are not using power from the tractor for *direct applications* as widely as possible. We are still limited too much by the "tractor" concept, that is, by thinking of the tractor, unconsciously if not consciously, as an "iron horse"—a pulling machine. However, the developments needed must be on the machine rather than on the tractor itself. As an example, take the evolution of the tractor-driven manure spreader. The first step was to shorten the tongue of a horse-drawn spreader and attach the tractor to the standard four-wheel, ground-driven spreader. The next step was a power take-off, a long shaft to a gear box at the rear end of spreader, substituting power by means of the take-off shaft for ground traction. This machine retained the relatively slow shredder cylinder and clumsy auger spreader or beater. Now, however, a preview of one make of postwar spreader shows the machine as a two-wheel trailer, with rubber tires and with front delivery, which maintains traction on the tractor wheels. For a spreading mechanism this machine apparently has two vertical, toothed disks operating at high speed which combine both shredder and beater functions and provide much simpler power transmission.

This paper was presented at a meeting of the Southwest Section of the American Society of Agricultural Engineers at Dallas, Texas, March, 1944.

HAROLD E. PINCHES is director of farm practices, Harry Ferguson, Inc.

Tillage is a field in which there are undeveloped possibilities for using some of the numerous forms of power of the tractor other than traction only. Here the tractor remains primarily a "pulling machine". Even modern tractors with mounted plows have not greatly changed the relationship of the plow to the soil or the way power is applied to the plow. The power is still applied to the plow through the plow beam, and the front end of the beam is attached to some point or points on the tractor instead of to a tractor drawbar. Power from the engine still has to get to the plow and to the soil indirectly by means of the traction of the drive-wheels on the ground.

As long as plows are pulled through the ground by means of power supplied to the drivewheels of the tractor, the tractor is still a "pulling machine". There still remains the problem of providing sufficient traction to get the plow through the ground under all conditions. As a result, for all uses other than tillage, tractors are compromised by the traction problems of tillage. The traction requirements for the difficult job of plowing or heavy disking determine to a large extent the form of the tractor and the power which it must have — power and characteristics which must be carried over into all other uses of the tractor throughout the year. In other words, the tractor is still a plowing tractor and consequently a *traction machine,* even when it is used on light jobs such as cultivating or pulling a hay rake or cutting hay, or any of the numerous jobs which together take up much more of the time of the tractor than tillage.

While results have not been good under most circumstances with rotary tillers, it must be possible somehow to apply power more directly to the soil, in ways and amounts that will reduce the traction problem, and which will at the same time leave the soil more nearly in good tilth with the tillage job completed at one operation, or at least in better condition than is done by the plow alone. It is hard to believe that all of the possibilities of direct application of power to the soil have been exhausted, and that we cannot progress beyond present types of plow and tractor combinations.

There is much to be done yet by all manufacturing companies in adapting implements to the fact that they are or can be tractor mounted, and then that they must be *dismounted.* If an implement such as a bulldozer is to be used continuously on one tractor, as on a large road-grading job or by the average earth-moving contractor, it does not matter very much how long it takes to bolt it to the tractor. But farm implements require quick and easy change. If a farmer's equipment is to meet the requirements on the average farm where a number of crops and enterprises are going on at the same time, it is often necessary to turn from one to another implement and use both of them in one day, or even three or four implements within the same day.

MAKING EQUIPMENT EASY TO MOUNT AND DISMOUNT

If we take seriously our obligation to returning soldiers, who will be returning to farming with some physical handicap, a great deal must still be done to make equipment easy to mount and dismount. However, even for able-bodied farmers there is still much to be done to make equipment easy to put on the tractor and easy to take off. Let us remember that while equipment is being mounted or dismounted (dismantled is a more exact description in some cases) both the tractor and the equipment are idle and the operator is doing "non-productive" work. He may be getting plenty tired, but he is not producing anything with which to pay the taxes.

Our aim should be, to attain with farm machinery ease and convenience of attachment and removal of implements comparable to the mounting of a portable electric motor which is made ready for use simply by dropping its slotted base rails over a crossbar and allowing it to tighten into the belt by its own weight. This may not be a practical method of attachment of farm implements, but it sets up a standard of efficiency, ease and convenience for such attachment.

The tractor is clearly apparent now as the universal basic center of all future farm machinery. Anyone who has paid any attention to farm operating costs recognizes the large element of cost which is machine cost, i. e., interest on investment and depreciation of investment in tractors and equipment. Any reduction that can be made in this cost will be reflected in cheaper and more efficient farming.

One step toward reduction of this cost is to be obtained from larger volume and consequent lower unit cost through keeping down the number of models of tractors and implements which go with them. Without knowing or even suggesting at this time how many types of tractors there should be, it still can be set forth that number of sizes of tractors should be rather limited. We should not allow the almost endless variety of machine types and sizes to dictate more sizes of tractors than absolutely necessary. The machines should be adapted to "unit" tractors, rather than vice versa.

This viewpoint may be illustrated by analogy. There are many details and dimensions possible in the construction of a particular building, and many designs and dimensions have been used in such a building. However, design is more and more standardizing the 4-in modular unit, whether the material is wood, steel, concrete block, or other building material. The standard gauge of railroad tracks throughout the whole continent is another example. Imagine the confusion and inefficiency in transportation if every railroad in this country had tracks differing from other railroads by a few inches, or even by fractions of one inch difference in width.

Carrying this thought over to agriculture, the minimum unit for planting equipment is one row. The row and row spacing is a basic factor, a modular unit for farm machinery design. However, we have a great many row spacings even with the same crop. Surely much can be done by agronomists and engineers working together to reduce the large number of row spacings now in use.

REDUCE THE LARGE NUMBER OF ROW SPACINGS

This may not mean as much restriction as it sounds like at first. The 4-in modular unit in building construction allows plenty of flexibility for all types and sizes of buildings. This does not mean that every 4-in interval is necessarily used. As you know, 16 in, 32 in, and 48 in are used very widely and have permitted standardizing of a great many materials so that they can be used with each other even though the materials are as unlike as a concrete block and a 4x8-ft sheet of building board.

In harvesting equipment the smallest unit possible is one tooth on the sickle. This small unit permits many different widths of cut in harvesting machines without very large differences in horsepower requirements. We have those different widths of cut without any very large difference in capacity, either in width of cut or horsepower requirements of the different machines. Certainly this variety must be more expensive in the long run than a smaller number of widths.

Even if there were no additional cost in the manufacturing of a variety of widths of harvesting machinery, there is need in connection with such soil-conserving practices and structures as strip cropping, terrace outlet channels, and sodded waterways for fewer and more standard unit widths of harvesting machines. Some of these conservation practices are based upon a round trip by a harvesting machine. If one machine is 42 in wide, and another is 48 in wide, and both are widely used in the same community, there is set up an unnecessary difficulty in relating machine use to the laying out of farms for soil and water conservation.

Finally, both implements and tractors need to be adapted to the average driver in the matter of speed, both speed of forward travel and the speed or time required for operational adjustments. One speed may be too slow, resulting in the operator working at low efficiency and even getting bored. A considerably higher speed might be possible, but be too exhausting. Somewhere between these two speeds there would be an optimum speed, permitting maximum output by the average workman throughout a normal working day.

These optimum speeds for various operations might be found to be not greatly different than those in use today. However, study of operator efficiency might point to the desirability of considerable changes. The techniques of time and motion economy as developed and applied in many industries with results that are often startling will no doubt be the methods by which to discover equal efficiencies in the operation of farm machinery.

Men have adapted themselves to tractors and implements for a long time. Have we not come far enough now in knowledge of mechanisms, of physiology and of psychology to consciously build machines for men, rather than asking men to continue to adapt themselves to machines? We have come to a stage of development where we can learn directly from experiences with farm machinery and from the application of principles learned in other industries with other types of operations. Considerable improvement in both operator efficiency and operator comfort should be possible.

(Continued on page 176)

Mulch Culture Tillage and Draft Requirements for Tillage Machinery

By Maurice B. Cox

DUE TO the great interest in producing more food per acre and at the same time conserving fertile topsoil, work was started on the Wheatland (SCS) Conservation Experiment Station at Cherokee, Oklahoma, to compare the effectiveness of mulch culture tillage with other methods of seedbed preparation. This work is being conducted on forty-eight plots and nine watersheds by the U. S. Soil Conservation Service and the Oklahoma Agricultural Experiment Station. At the beginning of the studies, the available machinery required was assembled and the tillage work started. The first attempts at mulch culture were with various sizes of common sweeps, ranging from 6 to 24 in. By the close of the first tillage operation, it was apparent there was definite need for tools better adapted for the purpose. Since that time many kinds of tools have been tried with varying results.

Standard Pressed Sweeps. Eight to 14-in sweeps functioned satisfactorily on short stubble that had only a small amount of straw and no vines. When bunches of straw, vines or large weeds were encountered, the shanks on which the sweeps were mounted acted much like a rake. The accumulation of such material caused much delay and often resulted in an uneven surface condition. The use of the 20 to 24-in sweeps aided slightly, but the shanks were still too close for good clearance and the wings would bend when hard spots in the soil were encountered.

Pence Sweeps. These sweeps are made of flat blade material forming a 42-in sweep with an angle of 90 deg between the cutting edges. The blades are welded to a forging that bolts to the side of a lister shank or similar implement. In operation these sweeps raise the soil slightly more than an inch. This size sweep operated without clogging seriously but was aided by the use of coulters. The objection found to these sweeps was that they did not agitate the soil sufficiently and much difficulty was encountered with breaking of the blades near the shank.

Plow Lay Sweeps. An attempt was made, by the use of right and left-hand plow lays, to construct a sweep that was large enough to prevent clogging with trash, heavy enough to prevent breaking and with enough lift to give good agitation to the surface of the soil (Fig. 1). These sweeps operated very well through trashy material and vines when used with coulters. The action upon the soil surface was good except that some ridging was caused which was objectionable for the use of a combine. The ridging may have been due to the long point that tended to break the soil ahead of the sweep and start the soil into a turning action. In operation these sweeps raised the soil approximately 2½ in.

This paper was presented at a meeting of the Southwest Section of the American Society of Agricultural Engineers at Dallas, Texas, March, 1944. A contribution of the Oklahoma Agricultural Experiment Station and the Soil Conservation Service, U. S. Department of Agriculture.

MAURICE B. COX is assistant agricultural engineer (cooperative agent) Red Plains Conservation Experiment Station (Guthrie, Okla.), Soil Conservation Service, U. S. Department of Agriculture.




Fig. 1 (Upper left) Plow lay sweeps constructed of right and left 16-in plow lays • Fig. 2 (Upper right) The wings of these sweeps are made of Raydex plow lay stock and attached to the frog by means of plow bolts. Two of the sweeps have the concave side of the wings on the upper side while the third has the convex side up. No apparent advantage was noted by either arrangement • Fig. 3 (Lower left) Blade tiller constructed of an 8-ft grader blade with convex surface on the upper side • Fig. 4 (Lower right) Blade tiller, shown in Fig. 3, mounted on lister shanks. Additional weight was necessary under some soil conditions, to aid in maintaining uniform penetration. The coulters shown in this illustration assisted in eliminating the accumulation of trash on the shanks

Tillage is a field in which there are undeveloped possibilities for using some of the numerous forms of power of the tractor other than traction only. Here the tractor remains primarily a "pulling machine". Even modern tractors with mounted plows have not greatly changed the relationship of the plow to the soil or the way power is applied to the plow. The power is still applied to the plow through the plow beam, and the front end of the beam is attached to some point or points on the tractor instead of to a tractor drawbar. Power from the engine still has to get to the plow and to the soil indirectly by means of the traction of the drivewheels on the ground.

As long as plows are pulled through the ground by means of power supplied to the drivewheels of the tractor, the tractor is still a "pulling machine". There still remains the problem of providing sufficient traction to get the plow through the ground under all conditions. As a result, for all uses other than tillage, tractors are compromised by the traction problems of tillage. The traction requirements for the difficult job of plowing or heavy disking determine to a large extent the form of the tractor and the power which it must have — power and characteristics which must be carried over into all other uses of the tractor throughout the year. In other words, the tractor is still a plowing tractor and consequently a *traction machine,* even when it is used on light jobs such as cultivating or pulling a hay rake or cutting hay, or any of the numerous jobs which together take up much more of the time of the tractor than tillage.

While results have not been good under most circumstances with rotary tillers, it must be possible somehow to apply power more directly to the soil, in ways and amounts that will reduce the traction problem, and which will at the same time leave the soil more nearly in good tilth with the tillage job completed at one operation, or at least in better condition than is done by the plow alone. It is hard to believe that all of the possibilities of direct application of power to the soil have been exhausted, and that we cannot progress beyond present types of plow and tractor combinations.

There is much to be done yet by all manufacturing companies in adapting implements to the fact that they are or can be tractor mounted, and then that they must be *dismounted.* If an implement such as a bulldozer is to be used continuously on one tractor, as on a large road-grading job or by the average earth-moving contractor, it does not matter very much how long it takes to bolt it to the tractor. But farm implements require quick and easy change. If a farmer's equipment is to meet the requirements on the average farm where a number of crops and enterprises are going on at the same time, it is often necessary to turn from one to another implement and use both of them in one day, or even three or four implements within the same day.

MAKING EQUIPMENT EASY TO MOUNT AND DISMOUNT

If we take seriously our obligation to returning soldiers, who will be returning to farming with some physical handicap, a great deal must still be done to make equipment easy to mount and dismount. However, even for able-bodied farmers there is still much to be done to make equipment easy to put on the tractor and easy to take off. Let us remember that while equipment is being mounted or dismounted (dismantled is a more exact description in some cases) both the tractor and the equipment are idle and the operator is doing "non-productive" work. He may be getting plenty tired, but he is not producing anything with which to pay the taxes.

Our aim should be, to attain with farm machinery ease and convenience of attachment and removal of implements comparable to the mounting of a portable electric motor which is made ready for use simply by dropping its slotted base rails over a crossbar and allowing it to tighten into the belt by its own weight. This may not be a practical method of attachment of farm implements, but it sets up a standard of efficiency, ease and convenience for such attachment.

The tractor is clearly apparent now as the universal basic center of all future farm machinery. Anyone who has paid any attention to farm operating costs recognizes the large element of cost which is machine cost, i. e., interest on investment and depreciation of investment in tractors and equipment. Any reduction that can be made in this cost will be reflected in cheaper and more efficient farming.

One step toward reduction of this cost is to be obtained from larger volume and consequent lower unit cost through keeping down the number of models of tractors and implements which go with them. Without knowing or even suggesting at this time how many types of tractors there should be, it still can be set forth that number of sizes of tractors should be rather limited. We should not allow the almost endless variety of machine types and sizes to dictate more sizes of tractors than absolutely necessary. The machines should be adapted to "unit" tractors, rather than vice versa.

This viewpoint may be illustrated by analogy. There are many details and dimensions possible in the construction of a particular building, and many designs and dimensions have been used in such a building. However, design is more and more standardizing the 4-in modular unit, whether the material is wood, steel, concrete block, or other building material. The standard gauge of railroad tracks throughout the whole continent is another example. Imagine the confusion and inefficiency in transportation if every railroad in this country had tracks differing from other railroads by a few inches, or even by fractions of one inch difference in width.

Carrying this thought over to agriculture, the minimum unit for planting equipment is one row. The row and row spacing is a basic factor, a modular unit for farm machinery design. However, we have a great many row spacings even with the same crop. Surely much can be done by agronomists and engineers working together to reduce the large number of row spacings now in use.

REDUCE THE LARGE NUMBER OF ROW SPACINGS

This may not mean as much restriction as it sounds like at first. The 4-in modular unit in building construction allows plenty of flexibility for all types and sizes of buildings. This does not mean that every 4-in interval is necessarily used. As you know, 16 in, 32 in, and 48 in are used very widely and have permitted standardizing of a great many materials so that they can be used with each other even though the materials are as unlike as a concrete block and a 4x8-ft sheet of building board.

In harvesting equipment the smallest unit possible is one tooth on the sickle. This small unit permits many different widths of cut in harvesting machines without very large differences in horsepower requirements. We have those different widths of cut without any very large difference in capacity, either in width of cut or horsepower requirements of the different machines. Certainly this variety must be more expensive in the long run than a smaller number of widths.

Even if there were no additional cost in the manufacturing of a variety of widths of harvesting machinery, there is need in connection with such soil-conserving practices and structures as strip cropping, terrace outlet channels, and sodded waterways for fewer and more standard unit widths of harvesting machines. Some of these conservation practices are based upon a round trip by a harvesting machine. If one machine is 42 in wide, and another is 48 in wide, and both are widely used in the same community, there is set up an unnecessary difficulty in relating machine use to the laying out of farms for soil and water conservation.

Finally, both implements and tractors need to be adapted to the average driver in the matter of speed, both speed of forward travel and the speed or time required for operational adjustments. One speed may be too slow, resulting in the operator working at low efficiency and even getting bored. A considerably higher speed might be possible, but be too exhausting. Somewhere between these two speeds there would be an optimum speed, permitting maximum output by the average workman throughout a normal working day.

These optimum speeds for various operations might be found to be not greatly different than those in use today. However, study of operator efficiency might point to the desirability of considerable changes. The techniques of time and motion economy as developed and applied in many industries with results that are often startling will no doubt be the methods by which to discover equal efficiencies in the operation of farm machinery.

Men have adapted themselves to tractors and implements for a long time. Have we not come far enough now in knowledge of mechanisms, of physiology and of psychology to consciously build machines for men, rather than asking men to continue to adapt themselves to machines? We have come to a stage of development where we can learn directly from experiences with farm machinery and from the application of principles learned in other industries with other types of operations. Considerable improvement in both operator efficiency and operator comfort should be possible.

(Continued on page 176)

Mulch Culture Tillage and Draft Requirements for Tillage Machinery

By Maurice B. Cox

DUE TO the great interest in producing more food per acre and at the same time conserving fertile topsoil, work was started on the Wheatland (SCS) Conservation Experiment Station, at Cherokee, Oklahoma, to compare the effectiveness of mulch culture tillage with other methods of seedbed preparation. This work is being conducted on forty-eight plots and nine watersheds by the U. S. Soil Conservation Service and the Oklahoma Agricultural Experiment Station. At the beginning of the studies, the available machinery required was assembled and the tillage work started. The first attempts at mulch culture were with various sizes of common sweeps, ranging from 6 to 24 in. By the close of the first tillage operation, it was apparent there was definite need for tools better adapted for the purpose. Since that time many kinds of tools have been tried with varying results.

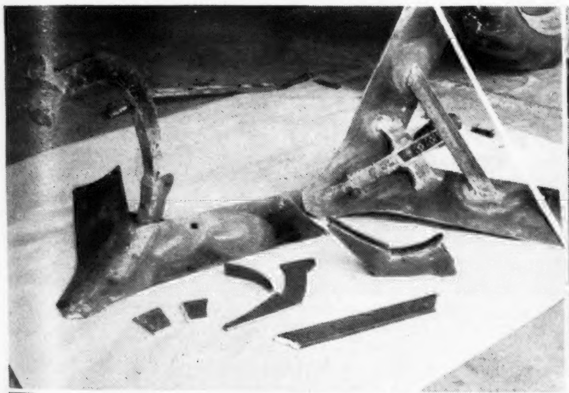
Standard Pressed Sweeps. Eight to 14-in sweeps functioned satisfactorily on short stubble that had only a small amount of straw and no vines. When bunches of straw, vines or large weeds were encountered, the shanks on which the sweeps were mounted acted much like a rake. The accumulation of such material caused much delay and often resulted in an uneven surface condition. The use of the 20 to 24-in sweeps aided slightly, but the shanks were still too close for good clearance and the wings would bend when hard spots in the soil were encountered.

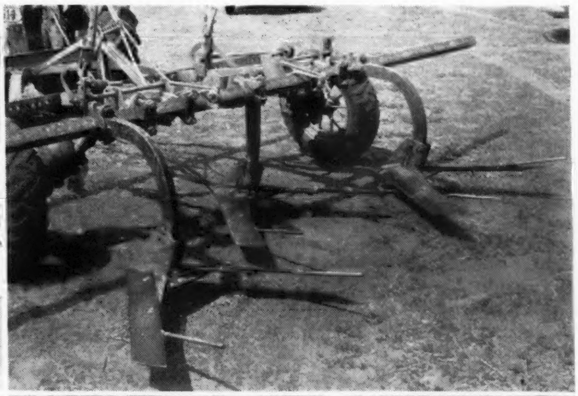
Pence Sweeps. These sweeps are made of flat blade material forming a 42-in sweep with an angle of 90 deg between the cutting edges. The blades are welded to a forging that bolts to the side of a lister shank or similar implement. In operation these sweeps raise the soil slightly more than an inch. This size sweep operated without clogging seriously but was aided by the use of coulters. The objection found to these sweeps was that they did not agitate the soil sufficiently and much difficulty was encountered with breaking of the blades near the shank.

Plow Lay Sweeps. An attempt was made, by the use of right and left-hand plow lays, to construct a sweep that was large enough to prevent clogging with trash, heavy enough to prevent breaking and with enough lift to give good agitation to the surface of the soil (Fig. 1). These sweeps operated very well through trashy material and vines when used with coulters. The action upon the soil surface was good except that some ridging was caused which was objectionable for the use of a combine. The ridging may have been due to the long point that tended to break the soil ahead of the sweep and start the soil into a turning action. In operation these sweeps raised the soil approximately 2½ in.

This paper was presented at a meeting of the Southwest Section of the American Society of Agricultural Engineers at Dallas, Texas, March, 1944. A contribution of the Oklahoma Agricultural Experiment Station and the Soil Conservation Service, U. S. Department of Agriculture.

MAURICE B. COX is assistant agricultural engineer (cooperative agent) Red Plains Conservation Experiment Station (Guthrie, Okla.), Soil Conservation Service, U. S. Department of Agriculture.





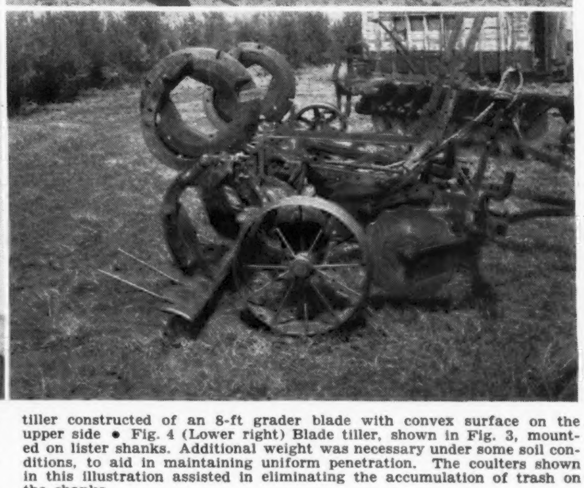


Fig. 1 (Upper left) Plow lay sweeps constructed of right and left 16-in plow lays • Fig. 2 (Upper right) The wings of these sweeps are made of Raydex plow lay stock and attached to the frog by means of plow bolts. Two of the sweeps have the concave side of the wings on the upper side while the third has the convex side up. No apparent advantage was noted by either arrangement • Fig. 3 (Lower left) Blade tiller constructed of an 8-ft grader blade with convex surface on the upper side • Fig. 4 (Lower right) Blade tiller, shown in Fig. 3, mounted on lister shanks. Additional weight was necessary under some soil conditions, to aid in maintaining uniform penetration. The coulters shown in this illustration assisted in eliminating the accumulation of trash on the shanks

Raydex Sweeps. Due to the difficulties encountered, assistance was asked of I. F. Reed of the USDA Tillage Machinery Laboratory at Auburn, Alabama. Mr. Reed has been of much help with suggestions and assistance in designing tools for the work. Sweeps constructed by the Laboratory consisted of blades cut from Raydex plow lay stock and fitted to the frog of a commercially made assembled sweep (Fig. 2). The blades were mounted on the frog with the concave surface on top and the cutting edges forming a 60-deg angle. The soil is lifted approximately 2 in with the blades in this position. Thirty-one and 38-in sweeps were constructed, both of which functioned satisfactorily. The action upon the soil was slightly greater than the Pence sweeps but not as severe as the plow lay sweeps. A distinct advantage of a large sweep of this kind is the ease of handling in sharpening.

Blade Tiller. This implement was constructed of an 8-ft grader blade mounted on plates that would allow it to be attached to the shanks of a three-bottom lister (Figs. 3 and 4). The blade operates with the convex surface on top and lifts the soil slightly more than two inches. Very little difficulty was encountered in getting it to go into the ground or to maintain uniform cutting, even in dry soil. The action upon the soil was similar to the Raydex sweeps with practically no ridging of the surface.

Disk Tillers. Disk harrows or one-way wheatland disks may be properly set to give fair results in obtaining mulch culture tillage. Old-style one-ways that were equipped with small shallow disks were much less effective in covering trash than the present deep-cup disk machines. Disks of any design if used on extremely dry soil may cause it to become highly pulverized.

RESULTS AND CONCLUSIONS

The job of tillage for seedbed preparation is not complete with merely cutting the roots of plants. There are several reasons for a more thorough job of tillage in the wheat areas. Some of these are stopping weed growth and the covering of shattered grain and weed seed. It appears from the various types of sweeps and blades tried that a combination of two or more tools might be advantageous for these operations. During seasons of extremely heavy growth of straw, it may be desirable to cultivate the soil shallow for the first tillage operation with a one-way wheatland disk plow. The plow lay sweeps agitate the soil and appear to do a fairly good job of covering shattered grain and weed seed. Succeeding operations with the Raydex sweeps or the blade tiller have eliminated the volunteer growth and weeds and aided in leveling the surface of the soil. During the past year the surface soil became very loose and it was necessary to use a soil packer following most of the tillage operations. It may be possible that packing after any sweep may prove beneficial.

Several of the subsurface tillage tools were equipped with bars welded to the back side of the blades to give a raking action to the underside of the furrow slice. This was done in an attempt to create more surface disturbance to the soil without covering the trashy material. It was found that these bars were of very little advantage under soil conditions at the Cherokee station.

DRAFT REQUIREMENTS FOR TILLAGE TOOLS

The investigation of draft requirements for tillage tools at the Cherokee station included eight different implements. These tools were all adjusted to operate at as near as possible the same depth and were pulled at approximately the same speed. Each tool was operated under two test runs of 300 ft each, on very uniform soil. The depth of penetration was accurately determined by measurements before and after tillage from a string stretched between stakes located outside the test strips. The time of travel over the measured distance was determined by stop watch, and soil samples were taken on either side of the furrow at three locations for moisture determinations. The draft of the implement was recorded by a Szekely recording dynamometer. The results of the tests are shown in Table 1. The comparison of draft requirements for the different tools can be determined from the pounds pull per square inch of furrow slice. These data show that the draft increases between the tools in the following order: Pence sweep, plow lay sweep, blade tiller, Raydex sweep, one-way plow, moldboard plow, lister, and basin lister. The reason for the high draft of the Raydex sweeps as compared to the other subsurface tools is not readily apparent. From inspection of the tools, they would appear to require no more power than the plow lay sweeps. The draft requirements of the lister and basin lister are based upon the dimensions of the soil moved out of the furrow. If the total width of the machine is considered with the bottoms spaced 42 in, the draft would only be one-third of the amount shown. With this tool, however, only one-third of the soil, to plow depth, is moved by a single operation. Additional tests should be made before definite power requirements are established.

TABLE 1. DRAFT TESTS ON WHEATLAND TILLAGE TOOLS AT CHEROKEE STATION, NOVEMBER, 1943*

Tool	Units or bottoms No.	Units or bottoms Size, in	Width of cut, in	Depth of cut, in	Miles per hour	Draft Total, lb	Draft Pounds per ft width	Draft Pounds per sq in†	Soil Moisture, per cent
Plow lay sweeps	3	32	93.0	5.35	2.63	2384	308	4.79	9.75
Pence sweeps	3	42	130.5	5.14	2.57	2778	255	4.14	9.99
Raydex sweeps	2	38	100.5	4.80	2.61	2919	348	6.06	10.11
Blade tiller	1	96	96.0	5.22	2.59	2836	355	5.67	10.42
Lister	3	14	42.0	6.60	2.68	2626	750	9.48	10.48
Basin lister	3	14	42.0	6.22	2.66	2752	786	10.53	10.45
One-way plow‡	1	72	73.5	4.68	2.58	2296	375	6.68	10.60
Plow	2	14	28.0	5.65	2.98	1140	489	7.20	9.93

*Data is average for two runs of 300 ft each.
†Pounds per square inch of furrow slice.
‡One-way wheatland disk plow, 26-in disks with 4-in cup.

Integrating Machinery with the Tractor

(Continued from page 174)

Much has been said in A.S.A.E. meetings from time to time about designing tractors for the operator's comfort, but the results so far have certainly been meager. Tractors are of course more comfortable to operate now than they were 20 to 30 years ago, but the progress in operator comfort has not been anywhere near equal to the improvement in tractors as machines for producing power and transmitting it.

Adapting implements and tractors to the efficiency of the operator and to the operator's comfort will have a great deal to do with the location and manner of operation of the controls. The controls on tractors generally are not so designed and located as to present the ease of manipulation of the controls on an automobile. Some conditions of tractor operation are similar to driving a car along an open country highway without much change of speed and without any change of gears. However, a great deal of tractor operation is fully as complex as the driving of a car through heavy traffic where speeds and gears have to be changed frequently.

In addition to operating a tractor under these conditions, there is the job of operating the equipment that goes with it. If we are to integrate the equipment with the tractor and make it possible for one man to do all of the work of steering the tractor and the equipment, controlling forward speed, and keeping the equipment adjusted for different operational conditions, the controls will have to be more than just odd-shaped handles that he can reach by contorting himself sufficiently to find them behind his back or around behind some other machine part.

In connection with industrial machines, it has been found that controls which at first glance look good often can be improved to provide greater ease, speed and precision of operation. Certain principles of design, of direction of operation and of power required to operate the controls have been worked out with machine tools for industrial use. These principles should be examined for translation to the controls on farm implements.

This all adds up to making the man, in a true sense, an *operator of a machine* which is furnishing power rather than making the man himself a *source of energy.* Man has never been and never will be a good source of mechanical energy. We can see now that farm machinery is going to be built around a tractor of some sort on which the operator will ride in a more or less restricted position. The least we can do is give thought to those conditions and make them as free as possible of fatigue-producing factors. Let us integrate the machine with the tractor, and the tractor with the machine, and then adapt both to the man who is going to operate them.

Need for Water-Yield Records from Small Drainage Basins

By M. T. Thomson
ASSOCIATE A.S.A.E.

THE growing complexities of modern life have created more and more specialized professions in which men devote more and more study to ever-narrowing fields. Thus we have a purely water-resources engineer addressing a group of agricultural engineers on a subject about which we all know something, but on a phase of which we apparently know very little. Frankly, any statement of mine that suggests a familiarity with agriculture is purely coincidental. However, I am familiar with the broad phases of water-resources problems and purpose to discuss water resources in relation to agricultural pursuits primarily in Georgia. While speaking of Georgia's problems, I do not believe that the questions are limited to Georgia alone but that they apply to most of the Southeast, and quite possibly to large areas of the eastern United States. Certainly these questions will apply to sections of the country that have climate, soil, geology and farming methods similar to those of Georgia.

Georgia is located in the humid part of the United States, having an average annual rainfall of about 50 in over most of the state with perhaps 70 in in the mountain provinces. While this abundant rainfall is usually considered an asset, it is actually not an unmixed blessing. The water causes severe leeching as it seeps down to the water table with the result that the soils of the state are largely deficient in plant nutrients. A tremendous amount of fertilizer is required because of this. More or less serious erosion has resulted from the heavy rains coupled with cropping practices which were inadequate to cope with the resulting runoff. In the past single-crop methods have been followed but in recent years there has been more and more diversification, application of rotation practices, and better soil-conservation methods.

One of the greatest difficulties encountered on Georgia land is the maintenance of adequate soil moisture. This fact is constantly brought out by agents and others who are familiar with the state. It is in part due to the small capacity of the soils to store moisture available for plants in contrast to the comparatively large capacity of the deep loam soils in many parts of the Middle West. Also the seasonal distribution of the annual rainfall is not best suited to agriculture for it is characteristically heavy in the spring and midsummer, with a definite dry spell in May or June and a severe dry period beginning in late September and usually running through October and, in some years, well into late November. This latter dry period makes the raising of fall gardens difficult, if not impossible, without irrigation. The earlier dry period is less harmful, although it can have serious consequences on certain crops such as corn if the drought occurs in a certain period that is critical in the forming of the ears. Without supplemental water at such a time it is possible to have complete failure of a corn crop. Tomatoes and other food crops also are subject to damage from this cause.

Where there is a heavy investment in a crop that is subject to early drought damage, as in a nursery for example, irrigation systems are sometimes installed. In south Georgia considerable areas in which tomato plants are grown are provided with irrigation systems.

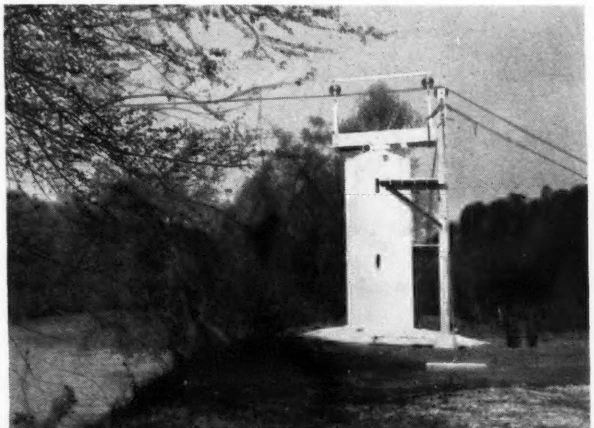
There are prospective developments other than irrigation which involve demands for water. Livestock raising and dairying are growing agricultural pursuits in Georgia and are strongly recommended. Both require abundant and dependable water supplies. Fish ponds are also being advocated and promoted. Many of the tenant families are moving away from the farms to industrial jobs. If they return after the war, or if those who remain are to be content, there will need to be a better living standard for the farm dweller. Even now tenants demand a good house with electricity and running water. It is a fairly simple problem to provide the house and electricity but not always simple to provide the water.

Possibly 90 per cent of the 2,000,000 rural population in Georgia now get their water from dug wells by the bucket-and-rope process. These wells sometimes fail but for the most part they will yield the 100 or 200 gal a day now used by a rural family. When the family needs only to turn the tap to get water, however, a great deal more will be used and not all the dug wells will produce the necessary volume.

To many individuals the question will then come up, "Where can I get the water and how much will it cost?" If the first part of the question can be answered, then the second part can be easily estimated. Literature on the subject now treats the second question at length, showing how to calculate cost of drilling, pipes, pumps, pressure tanks, fixtures and so on. The first, however, is disposed of by saying, "Consult your well driller." This takes a lot for granted — and is an unsatisfactory and inadequate procedure when dealing with so variable a resource as water and so intricate a subject as the occurrence and quality of the water that is available in different places.

One of our gauge observers raised this very question a few days ago. His house burned and he moved temporarily to his vacant tenant house across the road, perhaps a hundred yards away. The dug well at the main house used to fail every fall but the tenant house well was always adequate for both families. When he rebuilds he wants to install a water system and would like to drill a well to get the water. However, his neighbor paid $400 to have a well drilled and did not get a drop of water from it. What is he going to do for his water supply? If he were in the coastal plain region of south Georgia, he might get enough water out of a dug well, but he might get a more sanitary and reliable supply from a drilled well. Many dug wells are still used in the coastal plain although in 1941 there were 800 farm families in the vicinity of Moultrie, Ga., whose dug wells, as deep as 80 ft in some cases, failed. They were then obliged to carry water in barrels from an artesian well in the city.

Our records show that in almost any part of the coastal plain artesian water can be found in quantities adequate for any usual domestic need, although the conditions vary from place to place. Small farmers, however, cannot usually afford these wells, for they might cost more than the farm itself. As this is being written livestock in parts of



A typical stream gauging station in Georgia showing recorder shelter and cable car

This paper was presented at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1943, as a contribution of the Soil and Water Division.

M. T. THOMSON is district engineer, water resources branch, Geological Survey, U. S. Department of the Interior.

south Georgia are suffering from lack of water because the ponds and the swamps and streams on which they depend have dried up and not enough water can be obtained from wells for their needs. Eventually cooperative ownership of deep wells may solve a critical situation in this region. The question about water sources can generally be answered, even though the economic problem is not, for there is artesian water available in the area.

In the Piedmont region, occupying most of north Georgia, there are almost no artesian water supplies. Ground water comes from the decomposed rock of the subsoil or from fractures in the rock. In the past several years the Water Resources Branch of the U. S. Geological Survey has cooperated with the Georgia Department of Mines, Mining and Geology in a study of ground-water resources of the state. The investigations have recently been extended to the Piedmont region. Already the study has shown unsuspected supplies of moderate size from this section, but often the geologist finds the opposite condition — entirely inadequate supplies. The towns have been forced to abandon ground-water sources in favor of more adequate although costlier systems utilizing impounded small streams or larger rivers. County school superintendents are up against real problems when their wells give out. A small school cannot afford a filter plant on a surface supply. Many of the county schools were unable to put in canning units this year for the single reason that enough water was not available.

EXPERT ADVICE DESIRABLE BEFORE DRILLING

The answer to the water supply question in the Piedmont region requires more than the opinion of the local well driller. Drilling more wells or deeper wells may or may not provide enough water. A broader knowledge than that usually possessed by the local well driller is frequently desirable to determine the possibilities of securing more sanitary and reliable water supplies from properly constructed drilled wells that are sunk to the proper depth to tap adequate water-bearing formations. Some expert advice is needed on this problem, advice based on sound experience and study of facts gained by a systematic analysis of all the water sources.

Surface-water supplies from ponds or streams are not as well suited for some household uses—drinking, cooking, canning—as are supplies from wells and springs. However, they can supplement limited well supplies for sewage systems, stock, irrigation and fish ponds. Some surface water is used all over the state at the present time. The open-range system in the southern part of the state permits the stock to have access to swamp water and streams. Stock ponds are seen in all sections. There are more than 6,000 impoundments larger than 0.1 acre in Georgia. Streams of some size which have always flowed even in the worst drought year will supply ordinary farm demand. Yet many quite large streams dry up entirely once in a while. If a farmer is going to invest his money in a pump system to tap a small stream, he should have some assurance that the stream will supply all his needs. It is unwise to take anything for granted in a factor so vital as water supply. But where can a farmer learn the truth about the water yield of his small stream? If he asks the county agent, where will the county agent get the facts to give him? He can't look at a stream in May and tell what it will yield in October. He can't look at it in October and tell whether it will flow next October. If he consults the records at the experiment stations, he will find excellent data on storm runoff and soil losses from areas under different types of cover and he will find records on total yield and ground-water yield in Ohio or Texas or in Coweeta Forest. But these data will not tell him how much a specific branch in a Georgia county will produce.

The answers to questions pertaining to water resources are usually the responsibility of the state geologist or the equivalent state official. In most states there is cooperative program carried on between the state agencies concerned with water-resources problems and the Water Resources Branch of the U. S. Geological Survey. The programs differ in the several states according to the individual needs but fundamentally the work is a fact-finding investigation of water resources — surface water, ground water and quality of water. In Georgia and pretty generally in other states the surface-water investigations have been limited to streams on which major investments are made — streams to be developed for hydroelectric or steam power, navigation, flood control, major irrigation projects, municipal and industrial water supply and pollution control works.

Thus if the farmer or county agent consults the state geologist or the Geological Survey, he can find pretty definite information on this question if his stream is fairly large, say, draining 10 sq mi or more in north Georgia or 150 sq mi or more in south Georgia. However, if he is concerned with a smaller stream he will find but little reliable information. In Georgia and, I believe, in most other states this fact-finding program has not generally been applied to small drainage basins such as many farmers might be expected to use.

There is a gap in water-resources data between the experimental plots operated by the Department of Agriculture and the streams of public or commercial size commonly gauged by the Geological Survey. One might assume that the data collected by either agency would be subject to analysis so as to bridge the gap. In Georgia, however, recent investigations have demonstrated that analyses of existing information are not adequate.

One of the critical war problems in Georgia was to provide the best estimates possible of water supplies for camps and defense industries. In the course of this work low-water measurements of many small streams in north Georgia were obtained in 1942 and a study made to estimate the yield in the dry year 1941. Many discrepancies were found so that we were forced to limit our estimates to streams draining 10 sq mi or more. The causes of the discrepancies are known in a general sense to anyone familiar with hydrology yet methods of making quantitative estimates are not readily apparent. All of the factors influencing stream flow are involved. These include the underlying rocks, the rock structure, the soil and subsoil, the topography, cover, cropping practices and many others. We have not found over-all data available on these factors which might be correlated to stream flow. Possibly all these data may never be available to the extent that it will be possible to predict with approximate certainty what stream flow might be expected on small drainage basins. Rainfall-runoff studies while they are helpful on storm runoff do not supply information on low-water yield. Water levels in wells serve to some extent for predicting low flows. However, there is needed an expanded program of measurement of stream flow itself from small areas and correlative studies of the conditioning factors that have been mentioned.

UTILIZATION OF SMALL STREAMS PRESENTS PROBLEM

It is not feasible to pursue such a program on small streams as is done on large streams. It might cost more to gauge a small stream than it would to utilize it. Yet there may be reasonably accurate methods of doing such work without incurring prohibitive expense. One such scheme would be to establish a number of gauging stations on small streams representative of the different conditions with respect to the conditioning factors to serve as indexes of water yields and to show the daily and seasonal fluctuations. Then many of the small streams can be measured at critical times and a relationship established between any stream and the index streams. Likewise relations between geological, physiographic and other relevant factors can be developed so far as practicable for use in problems of water yield. From a survey of this nature, it would be possible for a competent hydrologist to visit a stream at almost any time, measure it and advise the farmer as to the probable dependable or low-water yield.

Enough work has been done along this line in Georgia to show that the scheme may be feasible. Not enough has been done for me to present concrete results at this time, nor can we estimate the cost of such a program on a county-wide or state-wide basis. The project should include systematic observations over a period of time and should cover one or more droughts as they are the critical periods.

The Geological Survey is the governmental agency authorized to study the nation's water resources in cooperation with state and lesser governmental agencies. It has the facilities and training to do this work. The federal and state departments of agriculture were created to handle farm and rural problems of all kinds. Their agents serve in an advisory capacity and demonstrate methods that are beneficial to our rural population. The rural water-supply problem is the concern of all these agencies and therefore calls for a close cooperation. Further cooperation in collecting data would be mutually beneficial. If the experiment stations were to assist in operating index stations and if the county agents would assist in so far as their time would permit in selecting gauging stations and observation wells and in collecting occasional data, the program would be materially advanced and the *(Continued on page 180)*

Expansion of Clay and Concrete Drain Tile Due to Increase of Temperature and Moisture Content

By Dalton G. Miller and Charles G. Snyder
FELLOW A.S.A.E. JUNIOR MEMBER A.S.A.E.

IT HAS been reported that examinations of the tile lines that have not functioned satisfactorily sometimes have revealed that the joints between individual tile appear to be too tight to permit ready entrance of water. The question arises whether the tile swelled after laying, or whether the trouble had not largely been the result of soil particles, especially the silt, clay, and colloidal fractions, forming a watertight seal at the joints of tile unusually true at the ends and perhaps butted too closely when laid. Under normal conditions, any length changes of drain tile are due to variations of temperature and moisture, and the following studies were made in order to determine the probable maximum changes of length due to these variables.

In order to study the factors causing changes in length, five or six 6-in tile 1 foot long were selected from the stockpiles of each of eight plants producing dry-tamped concrete products and eight clay products plants located in Minnesota and Iowa. Three tile from each plant were then selected for determination of length changes. The clay tile selected from a plant were judged to just about cover the range of burning, from soft to hard, for the ordinary commercial output. A Berry strain gage with a gage length of 8 in was used to measure between punch marks in the ends of stainless steel plugs. The plugs were set so that variations in length of the central portion of each tile could be measured at each of two gage lines. To minimize the possible effect of warping, the gage lines were placed diametrically opposite each other on the tile (Fig. 1). Lengths were measured to the nearest 0.0001 in.

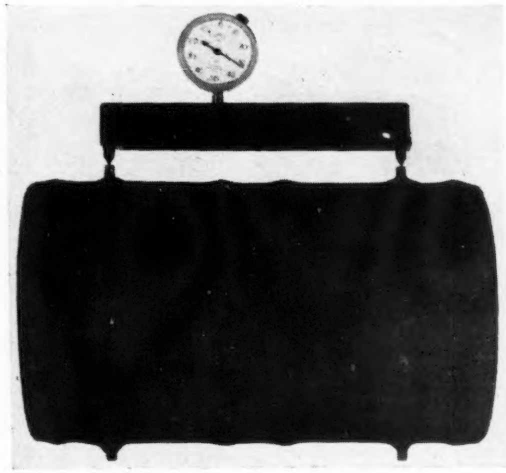


Fig. 1 Drain tile measured for length changes caused by variations of temperature and moisture

With the tile in room-dry condition, the measurements were made at temperatures of 40, 82, and 96 F (degrees Fahrenheit). These readings were used in calculating the thermal coefficient of expansion. (Tables 1 and 2).

The average coefficient of thermal expansion for the 24 clay tile per degree Fahrenheit was 0.0000025; this represents an expansion of 1.50 in per 1000 ft of clay tile due to an increase in temperature of 50 F. The coefficient for the dry-tamped concrete tile was 0.0000030. This represents an expansion of 1.80 in per 1000 ft of concrete tile due to an increase in temperature of 50 F. After the above readings were obtained, the tile were placed in tap water

This paper was prepared expressly for AGRICULTURAL ENGINEERING. (Paper No. 2131, Scientific Journal Series, Minnesota Agricultural Experiment Station. It is based on work conducted under a cooperative agreement of the Soil Conservation Service of the U. S. Department of Agriculture, the Minnesota Agricultural Experiment Station, and the Division of Water Resources and Engineering of the Minnesota State Department of Conservation.)

DALTON G. MILLER is senior drainage engineer, division of water conservation and drainage, Soil Conservation Service, U. S. Department of Agriculture, and CHARLES G. SNYDER is instructor in agricultural engineering, University of Minnesota.

TABLE 1. CHANGES IN LENGTH OF 6-IN CLAY DRAIN TILE DUE TO TEMPERATURE VARIATION AND SOAKING IN WATER

					Room dry (Relative humidity, 25 to 50 per cent)						Soaked in water at 68F		
Lab. No.	Absorption, %	Breaking strength, lb/ft	Thickness, in	Modulus of rupture*, lb/sq in	Gage readings at temperatures indicated, in 40F	82F	96F	Coef. of expansion per deg, 40-96F	Thermal expansion for 50F rise, in/1000 ft	82F room dry reading adjusted to 68F, in	Reading after 28 days soaking, in	Expansion due to wetting, in/in	Expansion due to wetting, in/1000 ft
8815	9.2	2260	21/32	1745	8.0309	8.0318	8.0321	0.0000027	1.62	8.0314	8.0317	0.000038	0.46
8816	18.9	1715	22/32	1215	8.0298	8.0308	8.0312	0.0000031	1.86	8.0304	8.0308	0.000050	0.60
8819	23.1	1270	22/32	900	8.0309	8.0317	9.0318	0.0000020	1.20	8.0314	8.0320	0.000075	0.90
Average	17.1	1750		1285				0.0000026	1.56			0.000054	0.65
8820	4.5	1895	18/32	1965	8.0306	8.0312	8.0314	0.0000018	1.08	8.0309	8.0312	0.000038	4.46
8821	2.0		18/32		8.0302	8.0309	8.0311	0.0000020	1.20	8.0306	8.0310	0.000050	0.60
8822	5.5	1910	18/32	1980		8.0302	8.0306	0.0000036	2.16	8.0297	8.0303	0.000075	0.90
Average	4.0	1900		1970				0.0000025	1.48			0.000054	0.65
8837	16.9	1315	19/32	1230	8.0307	8.0315	8.0317	0.0000022	1.32	8.0312	8.0320	0.000100	1.20
8839	18.7	1610	20/32	1365		8.0308	8.0311	0.0000027	1.62	8.0304	8.0314	0.000125	1.50
8841	19.2	1560	20/32	1325		8.0304	8.0307	0.0000027	1.62	8.0300	8.0305	0.000063	0.75
Average	18.3	1495		1305				0.0000025	1.52			0.000096	1.15
8843	1.7	1575	18/32	1635	8.0309	8.0318	8.0319	0.0000022	1.32	8.0315	8.0315	0.000000	0.00
8845	2.9	2170	18/32	2250		8.0314	8.0317	0.0000027	1.62	8.0311	8.0313	0.000025	0.30
8847	5.0	1950	18/32	2020	8.0301	8.0309	8.0312	0.0000025	1.50	8.0306	8.0307	0.000013	0.16
Average	3.2	1900		1970				0.0000025	1.48			0.000013	0.15
8850	8.3	1275	17/32	1475	8.0313	8.0321	8.0326	0.0000029	1.74	8.0317	8.0320	0.000038	0.46
8851	13.2	1045	18/32	1085	8.0306	8.0317	8.0319	0.0000029	1.74	8.0313	8.0324	0.000138	1.66
8853	10.2	1325	18/32	1375	8.0306	8.0317	8.0320	0.0000031	1.86	8.0313	8.0316	0.000038	0.46
Average	10.6	1215		1310				0.0000030	1.78			0.000071	0.86
8855	7.6	1260	19/32	1180	8.0306	8.0315	8.0318	0.0000027	1.62	8.0311	8.0316	0.000063	0.76
8857	8.0	1625	20/32	1380		8.0303	8.0311	0.0000027	1.62	8.0305	8.0311	0.000075	0.90
8859	10.7	1250	20/32	1060		8.0313	8.0314	0.0000009	0.54	8.0312	8.0315	0.000038	0.46
Average	8.8	1380		1205				0.0000021	1.26			0.000059	0.71
8861	6.3	1660	19/32	1550	8.0306	8.0313	8.0317	0.0000025	1.50	8.0310	8.0313	0.000038	0.46
8863	8.2	845	19/32	790	8.0307	8.0315	8.0318	0.0000025	1.50	8.0312	8.0314	0.000050	0.60
8865	8.8	1430	20/32	1215		8.0307	8.0310	0.0000027	1.62	8.0304	8.0308	0.000050	0.60
Average	7.8	1310		1185				0.0000026	1.54			0.000046	0.55
8867	8.4	1255	19/32	1175	8.0310	8.0318	8.0321	0.0000025	1.50	8.0315	8.0315	0.000000	0.00
8868	8.9	1355	18/32	1405		8.0309	8.0311	0.0000018	1.08	8.0307	8.0304	–0.000038	–0.46
8870	6.7	1315	18/32	1365		8.0311	8.0313	0.0000018	1.08	8.0309	8.0308	–0.000013	–0.16
Average	8.0	1310		1315				0.0000020	1.22			–0.000017	–0.21
Grand average	9.7	1520		1420				0.0000025	1.48			0.000047	0.57

*Modulus of rupture calculated by formula in Standard Specifications for Drain Tile, A.S.T.M. Designation C4-24. The results, so calculated, seem unduly high.

TABLE 2. CHANGES IN LENGTH OF 6-IN CONCRETE DRAIN TILE DUE TO TEMPERATURE VARIATION AND SOAKING IN WATER

					Room dry (Relative humidity, 25 to 50 per cent)						Soaked in water at 68F		
Lab. No.	Absorption, %	Breaking strength, lb/ft	Thickness, in	Modulus of rupture*, lb/sq in	Gage readings at temperatures indicated, in 40F	82F	96F	Coef. of expansion per deg, 40-96F	Thermal expansion for 50F rise, in/1000 ft	82F room dry reading adjusted to 68F, in	Reading after 28 days soaking, in	Expansion due to wetting, in/in	Expansion due to wetting, in/1000 ft
8790	[illegible]		20/32		8.0307	8.0319	8.0324	0.0000038	2.28	8.0315	8.0362	0.00059	7.08
8793	[illegible]	1475	21/32	1140	8.0303	8.0313	8.0317	0.0000031	1.86	8.0310	8.0360	0.00062	7.44
8794	9.1	1510	22/32	1070	8.0305	8.0319	8.0322	0.0000038	2.28	8.0315	8.0364	0.00061	7.32
Average	9.2	1490		1105				0.0000036	2.14			0.00061	7.28
8795	10.4	2465	24/32	1480	8.0300	8.0311	8.0314	0.0000031	1.86	8.0308	8.0341	0.00041	4.92
8797	11.3	1530	24/32	920	8.0298	8.0308	8.0308	0.0000022	1.32	8.0306	8.0339	0.00041	4.92
8798	9.4	1935	22/32	1160	8.0301	8.0312	8.0314	0.0000029	1.74	8.0309	8.0341	0.00040	4.80
Average	10.4	1975		1185				0.0000027	1.64			0.00041	4.88
8801	13.9	955	21/32	740	8.0300	8.0308	8.0310	0.0000022	1.32	8.0306	8.0333	0.00034	4.08
8802	12.8		20/32		8.0306	8.0316	8.0317	0.0000025	1.50	8.0313	8.0340	0.00034	4.08
8803	15.0	650	21/32	500	8.0297	8.0306	8.0307	0.0000022	1.32	8.0304	8.0327	0.00029	3.48
Average	13.9	800		620				0.0000023	1.38			0.00032	3.88
8806	11.5	1130	20/32	960	8.0306	8.0316	8.0319	0.0000029	1.74	8.0313	8.0350	0.00046	5.52
8807	10.3	1190	20/32	1010	8.0304	8.0311	8.0318	0.0000031	1.86	8.0308	8.0350	0.00052	6.24
8809	8.6	1425	19/32	1335	8.0301	8.0314	8.0319	0.0000040	2.40	8.0310	8.0349	0.00049	5.88
Average	10.1	1245		1100				0.0000033	2.00			0.00049	5.88
8810	9.3	1950	22/32	1380	8.0298	8.0309	8.0310	0.0000027	1.62	8.0306	8.0341	0.00044	5.28
8813	9.1	2000	22/32	1415	8.0304	8.0314	8.0317	0.0000029	1.74	8.0311	8.0345	0.00042	5.04
8814	9.9	1855	22/32	1310	8.0306	8.0317	8.0320	0.0000031	1.86	8.0314	8.0355	0.00051	6.12
Average	9.4	1935		1365				0.0000029	1.74			0.00046	5.48
8826	8.5	1430	20/32	1215	8.0299	8.0311	8.0313	0.0000031	1.86	8.0308	8.0346	0.00047	5.64
8829	9.6	1090	18/32	1130	8.0303	8.0313	8.0316	0.0000029	1.74	8.0310	8.0353	0.00054	6.48
8830	10.2	1040	18/32	1080	8.0305	8.0317	8.0318	0.0000029	1.74	8.0314	8.0350	0.00045	5.40
Average	9.4	1185		1140				0.0000030	1.78			0.00049	5.84
8831	8.2	2005	20/32	1700	8.0310	8.0321	8.0324	0.0000031	1.86	8.0318	8.0353	0.00044	5.28
8832	8.7	1795	21/32	1385	8.0309	8.0322	8.0326	0.0000038	2.28	8.0318	9.0354	0.00045	5.40
8834	10.2		21/32		8.0301	8.0313	8.0315	0.0000031	1.86	8.0310	8.0350	0.00050	6.00
Average	9.0	1900		1540				0.0000033	2.00			0.00046	5.56
8873	8.9	1310	19/32	1225	8.0303	8.0312	8.0314	0.0000025	1.50	8.0309	8.0343	0.00040	4.80
8874	9.4	1365	19/32	1775	8.0304	8.0314	8.0317	0.0000029	1.74	8.0311	8.0345	0.00042	5.04
8877	8.6	1340	18/32	1390	8.0298	8.0308	8.0311	0.0000029	1.74	8.0305	8.0346	0.00051	6.12
Average	9.0	1340		1460				0.0000028	1.66			0.00044	5.32
Grand average	10.1	1495		1205				0.0000030	1.79			0.00046	5.51

*Modulus of rupture calculated by formula in Standard Specifications for Drain Tile, A.S.T.M. Designation C4-24. The results, so calculated, seem unduly high.

and measured at weekly intervals. Expansion had practically stopped after 21 days in water, and the 28-day measurement was used to determine the expansion due to wetting. The average expansion due to wetting of the 24 clay tile was 0.00005 ft per ft of length. For 1000 ft of clay tile this amounts to 0.60 in. The expansion of the 24 dry-tamped concrete tile was 0.00046 ft per ft of length. For 1000 ft of concrete tile this amounts to 5.52 in.

In practice, the most unfavorable conditions for drain tile with respect to expansion would be when dry cold tile were laid. Assuming 50 F as the extreme probable rise in temperature after installing tile on very cold days, 1000 ft of clay tile would expand 1.50 in due to temperature rise and 0.60 in due to wetting, making a total expansion of 2.10 in per 1000 ft, or 0.00210 in at each joint per tile 1 ft long. Assuming the same conditions for concrete tile, expansion due to 50 F increase of temperature would amount to 1.80 in, and from wetting to 5.52 in, a total of 7.32 in per 1000 ft for concrete tile, or 0.00732 in for each joint of tile 1 ft long.

Actually, in practice, tile are seldom installed under the temperature conditions assumed, as in most cases tile in the trench will be subjected to temperatures lower than when lying on the ground along the trench and consequently will shrink somewhat due to temperature change; also, tile are rarely in a room-dry condition when installed so expansion due to moisture increase will ordinarily be considerably less than the extremes cited. For practical purposes, it is doubtful that much consideration need be given the matter of expansion after laying of either clay or concrete drain tile because of temperature changes in so far as the effectiveness of a tile line is influenced. Neither does it appear that the magnitude of change due to wetting is of much importance in connection with the efficiency of a tile line of clay tile. On the other hand, concrete drain tile taken from a stockpile following a protracted period of hot dry weather and installed in a trench while still dry could conceivably expand in the neighborhood of a half inch per hundred feet due to wetting. This elongation could be of enough magnitude to cause trouble perhaps by buckling of the line at some place, but here again it is rather in the nature of possibility than anything likely to occur in connection with the use of drain tile.

CONCLUSIONS

It appears from these studies that it is improbable that expansion of clay tile after installation, due either to increase of temperature or to increase in moisture content, is of sufficient magnitude to impair the effectiveness of a tile line. The same may be said of dry-tamped concrete tile as regards expansion due to temperature changes, but some precaution should be exercised not to install concrete tile when too dry. Under anything like ordinary conditions, concrete drain tile which have lain on the ground for a few days previous to installation will have absorbed enough moisture to just about eliminate the possibility of undue expansion following installation.

It is believed that waterseal of the joints of a tile line, if such occurs, is chiefly attributable to unduly close butting of tile with extremely true ends, to sealing of the joints by soil fractions, or to a combination of the two factors, rather than to expansion of the tile because of temperature and moisture increases, although temperature and moisture increases could be contributing factors.

Need for Water-Yield Records from Small Drainage Basins

(Continued from page 178)

results would be more valuable. The same effort would assist the agricultural personnel to become familiar with the type of data available and its limitations, making them better able to assist those whose interests they serve.

Individual farm water supplies do not involve large sums of money. Yet the aggregate investment all over the country is undoubtedly a considerable sum. It seems only proper therefore that government agencies should satisfy the demands of many small investors for adequate water-resources information just as well as the needs for large investments are now supplied.

I regret that this does not permit a detailed discussion of water-resources investigations nor of the information now being collected in Georgia. Perhaps at some later date we may have the opportunity to present some concrete results of that work. It was interesting to note in Howard Matson's article "More Farm Ponds Needed," in AGRICULTURAL ENGINEERING for November 1943, that in eight of the twenty considerations he listed for planning farm ponds, he would use data obtainable from stream-flow records, data which in parts of Georgia at least and very likely in much of the country is limited, if not unobtainable, at this time.

Studies of Raindrop Erosion

By W. D. Ellison
MEMBER A.S.A.E.

(Continued from the April issue)

MATHEMATICAL ANALYSIS OF DATA

The only data treated mathematically were those relating to the effects of rainfall variables on quantities of soil intercepted with the samples of raindrop splash. This analysis was made by H. W. Alexander and statements taken from his report are quoted as follows:

"*Regression Analysis of Splash Experiment Data.* The following analysis is based upon the data from the 59 experimental runs shown in Table 5.

"Preliminary graphing suggested an exponential relationship as the appropriate one. Hence it was decided to fit a relationship of the form

$$E = k\ V^a d^b I^c \qquad [1]$$

where E = grams of soil carried by the samples of splash in a 30-min run

V = drop velocity in feet per second

d = diameter of drops in millimeters

I = intensity in inches per hour

and k, a, b, and c are the constants to be determined. In logarithmic form, formula [1] is written

$$\log E = a \log V + b \log d + c \log I + \log k \qquad [2]$$

"The process used was that of fitting a relationship of the form 1 by the method of least squares. This is equivalent to fitting a relationship of the form 2 by the method of least squares, provided that each of the original observations is given a weight proportional to E^*. The loss of accuracy is not great if an average weight is assigned to a group of points. In the computations that follow, an average weight was assigned to each of the three sets of experimental values corresponding to the three distances of drop fall.

"The F-test was used to evaluate the significance of the whole relationship, and the t-values for each of the coefficients a, b, and c were computed to evaluate their significance. These values are shown in Table 10.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

W. D. ELLISON is project supervisor, North Appalachian Experimental Watershed, Soil Conservation Service, U. S. Department of Agriculture.

*Leland, O. M. Practical Least Squares. 1921. Page 136.

TABLE 10

	a	*b*	*c*
Coefficients	4.33	1.07	0.65
Standard error	0.31	0.16	0.066
Value of t	13.98	6.72	9.85

"For 55 degrees of freedom, all of the t-values are highly significant. The F-value for this relationship is 143.17 and it is also highly significant.

"The preliminary graphing suggested that the relationship between E and V might be sufficiently curvilinear to justify including another term in V. Hence the relation

$$E = k\ V^a\ d^b\ I^c\ 10^{eV}$$

or in logarithmic form

$$\log E = a \log V + b \log d + c \log I + eV + \log k$$

was fitted. The coefficients, their standard errors, and their t-values are given in Table 11.

TABLE 11

	a	*b*	*c*	*e*
Coefficient	8.8	0.95	0.53	1.39
Standard error	4.2	0.16	0.048	1.11
Value of t	2.12	6.01	10.96	1.26

The F-value here is 121.02. Comparing the t-values in Table 11 with those in Table 10, as well as the corresponding F-values, it appears that there is no gain in including the additional factor 10^{eV}.

"The best fitting relationship as established by the analysis is thus the one given by equation 1 with the values shown in Table 10, or

$$E = .00007661\ V^{4.33}\ d^{1.07}\ I^{.65} \qquad [3]$$

Curves for this equation are shown in Figs. 9 and 10."

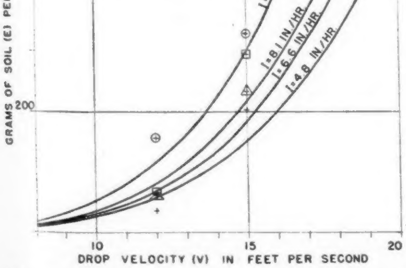
SUMMARY AND CONCLUSIONS

It may be helpful to review the problem of raindrop erosion and consider what part of the whole is covered by these studies before summarizing findings and attempting to draw conclusions. For purposes of review the problem has been divided into four parts: (1) the storm, (2) the soil, (3) the slope of the surface, and (4) the vegetal canopies, mulches and other materials which impede the fall of raindrops and the movement of raindrop splash.

Since only one soil type, one slope, and no vegetal covers were tested, studies of relationships of the variables must be limited to (1) above (the storm). Nor were studies of the first part of this problem (the storm) completed. The storm variables include both rainfall and wind. In reference to the rainfall, a wider range of drop velocities, drop sizes, and rainfall intensities must be tested. And concerning the effects of wind which may be anticipated include its influences on the angle of fall and strike of the raindrops, and transporting of splashed materials. The wind may also cause velocity changes and these must be studied, but the effects of these velocity changes are shown in formul [3].

Returning now to the specific results obtained, three distinct actions in the raindrop erosion processes, which may be harmful to the land, were found to be associated with raindrop impact and splash. These are (1) displacement and transportation of the soils, (2) changing the clear rainfall water to a mixture of water and soil materials preceding infiltration, and (3) breaking down soil aggregates.

Specific amounts of soil materials displaced and transported by splash on each unit of surface area have not been studied, but some



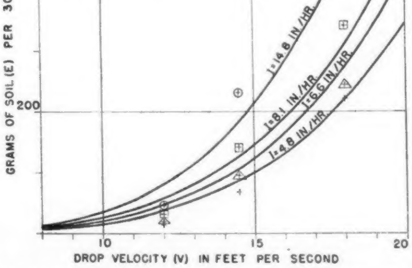


Fig. 9 (Left) Average observed quantities of soil (E) in raindrop splash plotted against drop velocity (V), and curves of $E = 7.66(10)^{-5}V^{4.33}d^{1.07}I^{0.65}$ for drops of 5.1 mm diameter • Fig. 10 (Right) Average observed quantities of soil (E) in raindrop splash plotted against drop velocity (V), and curves of $E = 7.66\ (10)^{-5}V^{4.33}d^{1.07}I^{.65}$ for drops of 3.5 mm diameter

results of this action are shown in Figs. 1 and 2. Figs. 3, 4, and 5 show raindrops falling and particles of soil and water splashing up from the soil surface. The relative effects of rainfall intensity (*I*), drop size (*d*), and drop velocity (*V*), in causing soil to splash are shown in Table 5, and mathematical relationships of these data are shown in formula [3]. Formula [3] indicates that only small changes in velocities of raindrops may cause large differences in quantities of soil carried by the splash.

Fig. 7 indicates that greater amounts of soil are carried by the splash after the surface becomes covered with a film of water. This seems partly due to a reduction of the cohesive forces working between the soil particles, and it is perhaps due in part to changes in splash phenomena which occur with changes in the depth of the water film covering the soil. This figure also indicates a reduction occurs in the rate of soil splash after the surface has become sealed and the loose particles above the plane of sealing have been carried away by erosional processes.

Tables 6, 7, and 8 show the amounts of soil caught in upper and lower sides of splash samplers when the sampler was installed with the splash plates perpendicular to the direction of slope. About three times as much soil was caught in the uphill side of samplers as was caught in the downhill side and this would seem to indicate that three parts of the soil splash were moved downhill, while only one part was being moved uphill on this 10 per cent slope. The probable effects of such action become more apparent when this part of the study is referenced to Fig. 1 (C); had one-half the soil lost from this surface been transported down slope, downhill movement caused by raindrop splash would have been very appreciable.

In reference to raindrop impact and splash which changes the rainfall from clear water to mixtures of water and soil materials, data relating to the soil content of these mixtures are shown in Tables 1, 2, 5, and 9. Rates of infiltration may be very sensitive to changes in the soil content shown in these tables. Also, the soil content of surface flow, especially in prechannel stages, may be proportional to the soil content of the raindrop splash. This is shown to be the case when comparing Figs. 7 and 8. Note similarity of recession curves and that they both break at about 10 minutes after beginning of rainfall.

Breaking down of the soil aggregates under raindrop impact is indicated by the data in Tables 2, 3, and 4. Under this impact many of the aggregates too large to be carried by raindrop splash were broken down. This breakdown made more small aggregates of sizes readily carried by the raindrop splash and transported by the surface flow.

The data in Tables 2, 3, and 4 indicate that the degree of breakdown of a soil aggregate is not sensitive to changes in drop size and velocity, at least not under the conditions of these tests. This information supports a conclusion that the total aggregate breakdown for a particular soil will be proportional to the total number of aggregates involved in the erosional processes. These totals may be represented by *E* in formula [3]. Therefore, the total aggregate breakdown is proportional to 0.00007661 $V^{4.33}\ d^{1.07}\ I^{.65}$. The structure of soil pores may be changed by a breakdown of the aggregates, and these changes are certain to have an effect on infiltration and runoff.

Experimental studies of the soil aggregate and particle sizes contained in the raindrop splash and in the surface flow indicate that the raindrop splash carries higher percentages of large particles and aggregates than does surface flow in the prechannel stages as represented on this plot.

Experimental results indicate that in addition to measures of rates and quantities of precipitation that are now being made in most watershed studies, there is an outstanding need for measuring drop sizes and drop velocities of natural rainfall.

Fig. 1 (C) indicates that particles of splash rising from the surface do not have sufficient size and velocity to cause erosion when they again strike the soil. If they were capable of this, they would have destroyed the vertical sides of soil columns contained under the coins.

Since infiltration depends on both (a) properties of the soil through which the water must filter and (b) properties of the water that is to be filtered, raindrop erosion which changes properties of both is certain to be a most important factor affecting the infiltration process.

Results of these studies suggest a need for infiltration experiments where both quantities and physical properties of soil materials contained in raindrop splash are manipulated and studied as independent variables.

It is recognized that high concentration of soil in the runoff water may be caused by either (a) excessive erosion in a few localized gullies and channels or (b) high rates of erosional activity over the entire watershed surface. If it is caused by the former, it will probably bear little relationship to infiltration and runoff on the entire watershed. If it is caused by the latter, it may indicate that the entire surface of the watershed is covered by a mixture of muddy water and this should have considerable bearing on rates of infiltration and runoff. Before attempting to analyze runoff and associated erosional data on a watershed basis it would seem desirable and even necessary to study erosional activity on the entire watershed. Where this is not done, the relationships of erosion, infiltration and runoff cannot be determined.

Since erosional activity reacts so sensitively to changes in raindrop velocities, it will be important to study methods of controlling these velocities under field conditions. Considerable work is now being done with mulches which partially control the delivery of raindrops to the soil surface. However, most mulches that are of practical use are probably not as effective as many vegetal canopies. Perhaps the effectiveness of the canopies may be improved by developing lower growing plants and through better use and improved distribution of canopies in the land use plans.

Vegetal canopies in addition to reducing high raindrop velocities approaching the soil surface also impede the movement of soils in the splash process and thereby curtail soil loss from the sloping areas; they may also prevent winds from carrying the splash any considerable distances.

Since the splash and not the surface runoff seems to carry the larger particle and aggregate sizes, and since erosional deposits along the bases of many slopes are often composed of coarse textures and large aggregates, the question is asked as to whether the downhill splash of raindrops does not account for some of the erosional deposits found near the bottoms of many hillsides. Results of these experiments indicate that it probably does, and that this question should be given further study. Determinations of particle and aggregate sizes carried by raindrop splash and surface flow under field conditions may make it possible to identify the erosional deposits caused by each.

The results of raindrop erosion are most apparent at the tops of hummocks and hills, where return splash does not balance outgoing splash. It is the author's belief that most of the severe sheet erosion found at these locations is largely caused by raindrop splash.

Erosion by surface flow is usually most apparent near the base of the slope where greatest amounts of surface flow concentrate.

The many detrimental processes involved in raindrop erosion may be more damaging on some types of soils than are gullying and other forms of erosion caused principally by runoff. Since raindrop erosion may cause infiltration curves to make a sharp downward break at the beginning of the rainstorm, and the runoff curves to make a sharp upward break, it is apparent that infiltration and runoff are dependent on raindrop erosion and that prevention of raindrop erosion through use of canopies and mulches represents a basic approach to the broader problems of soil and water conservation and floods. Research work necessary to achieve most effective use of these covers must be based on many considerations. A study of raindrop splash and the erosional activity associated with this splash seems to represent a step in the right direction, and provides a means for making better evaluations of soil and water conservation practices which may be applied to the lands.

ACKNOWLEDGMENTS

The author expresses sincere thanks to the following persons:

C. E. MacQuigg, dean of engineering, Ohio State University, for university equipment and for his advice and consultation which helped to guide the work.

R. W. Powell, professor of mechanics, Ohio State University, for assisting with formulation of plans and with analyses.

R. E. Yoder, chief in agronomy, Ohio State Agricultural Experiment Station, for suggestions and for use of station equipment.

F. R. Dreibelbis, soils technologist, Coshocton Project, for supervision of mechanical and aggregate analyses of samples, and for suggestions.

W. H. Pomerene, agricultural engineer, Coshocton Project, for assisting with design of rainfall applicator used, and for suggestions.

H. W. Black, soil conservationist, Coshocton Project, for suggestions.

D. A. Parsons, project supervisor, U. S. Soil Conservation Service, Auburn, Ala., for review and criticism of preliminary manuscript.

Members of C. P. S. Camp No. 23, for suggestions, for assisting with the experiments, and for work on the mathematical, mechanical and aggregate analyses.

Results of a Farm Survey of Frozen Food Units

By D. Emerson Wiant

MEMBER A.S.A.E.

FROZEN food units are popular and in demand in Michigan because (1) 140,000 Michigan farms have high-line electric service; (2) the state produces a great variety of fruits and vegetables excellent for freezing and many families raise their own pork, beef, and poultry; (3) there are 40 cities with populations of 10,000 or more and many of the people working in the cities live in the surrounding territory and raise their own fruit and vegetables; (4) a considerable amount of both small and large game and fish are taken in the state every year, and (5) the state enjoys a large tourist trade.

In 1943 the author and Richard L. Witz, extension agricultural engineer, Michigan State College, conducted a questionnaire survey among owners of frozen food units in Michigan to determine (1) size (cubical content) of cabinets that users are buying, and reasons for size chosen, (2) whether unit is homemade or manufactured, (3) whether owner is satisfied with size, (4) where units are located, (5) products frozen, (6) portion of fruits, vegetables, and meats frozen, (7) use, if any, made of community locker plant, (8) if user believes chilling room (34-38 F to cool meat before cutting and wrapping) is necessary, (9) if user is satisfied with unit. Following is a summary of the results of the survey:

A total of 105 owners filled out and returned our questionnaires, and out of the 105 units 6 were homemade.

Following is a tabulation of sizes of present unit, and the sizes owners would buy again:

	Size of unit*						
	1-10	10½-15½	17-17½	20-29	30-39	40-	Not given
No. of units in each range	32	19	25	14	3	2	10
No. of owners who:							
Would buy same size	15	12	16	10	0	1	
Would buy larger	14	3	7	3	1	0	
Would buy smaller	0	0	0	0	2	0	
No reply	3	4	2	1	0	1	

*Capacity given (in cubic feet) includes total freezing and storage space

The following table shows the relation between cubic feet capacity per person and number in the family:

No. in family	No. of units	Range in size of units (cu ft)	Cu ft per person
3	14	6-24	4.62
4	26	4-25	3.25
5	24	4-24	2.8
6	17	6-40	2.5
7	5	10-17	1.97
		Average of 79 units —	3.05

The distance from town does not influence the size of unit purchased. Twelve owners live 8 miles or more from town. Nine of the 12 reported the size of unit and number in family. The size of the home units ranges from 6 to 40 cu ft, averaging 16.9 cu ft per unit, or 3.3 cu ft per member of the family.

Only a few owners use additional storage space at locker plants. Nine owners use a locker at their community locker plant for additional storage. Eight of these live 8 miles or less from the locker plant, and one lives 20 miles. The units range in size from 6 to 40 cu ft, or from 1.4 to 2.6 cu ft per person.

Sixty-one of 91 owners reporting, keep their frozen food units in the basement, 15 in the kitchen, 5 on the porch, 4 in the garage, and others are kept in the smokehouse, milkhouse, dining room, or hall.

Thirty-four owners live within 5 miles of a locker plant, 34 between 6 and 10 miles, 19 between 11 and 18 miles, five live 25 miles, and three more than 25 miles from a locker plant.

Seventy-one owners butcher on the farm, six do some butchering, and 25 do none. Four get butchering done at locker plant, 23 at packing plant or slaughter house, and one buys all meat dressed.

Sixty-one say they do not need a chilling room (34F), while 34, each of whom freezes an average of 194 lb of meat at a time, think a chilling room necessary. Seventeen of the 34 freeze all and eight freeze three-fourths of their meat.

Seventy-four use no service offered by the community locker plant. Nine use lockers in addition to their own unit. Other locker plant services used are: 9 cutting, 6 wrapping, 4 butchering, 4 freezing, 3 hanging, 3 curing, 3 smoking service, and 3 buy supplies.

Percentage of Total Products Various Owners Preserve by Freezing

	Number of owners who freeze				
Product	100%	75%	50%	25%	10%
Meat	50	29	13	3	0
Fruits	17	12	14	19	1
Vegetables	17	12	19	17	0

Nine owners freeze 100 per cent of their meats, fruits, and vegetables, and the number of cubic feet per member of family for these 9 families ranged from 0.86 to 7.15, or an average of 2.78 cu ft. One owner, with a unit of 12 cu ft capacity and a family of 6, found it necessary to rent additional storage space at a community locker.

Ninety-nine owners freeze pork, 100 beef, 65 poultry, 21 lamb, 14 veal, 17 fish, and 5 freeze game. Twenty-six owners freeze 50 lb or less at a time; 12, 50-100 lb; 6, 100-150 lb; 6, 150-200 lb; 2, 200-250 lb; 6, 250-300 lb; 1, 300-350 lb; 3, 350-400 lb; 1, 400-450 lb; and 6, 450-500 lb. Evidently 10 users freeze a whole beef at a time.

Thirty-four owners freeze asparagus, 44 beans, 53 peas, 39 corn, 5 greens, 4 peppers, 2 limas, and 3 freeze spinach.

Eighteen freeze strawberries, 54 berries, 26 cherries, 22 peaches, 6 rhubarb, 3 pineapples, and 2 freeze pears.

Ninety-eight of the 105 owners stated that they are satisfied with their units, with the exception of size.

Five owners reported the following mechanical troubles: chipping of enamel and rusting, sweating on the outside, operating trouble, and doors freezing shut.

Two owners are not satisfied with their frozen meat; one reported that meat dried out, and the other reported that a rancid taste developed after 4 or 5 months' storage.

Nine owners reported unsatisfactory results with some fruits and vegetables and at the same time reported satisfactory results with others. All fruits reported unsatisfactory when frozen were reported satisfactory by other users. Frozen beets, cucumbers, and radishes were reported as unsatisfactory by one owner, and no one reported them satisfactory.

It cost 18 users with units of 10 cu ft or less $1.65 per month; 12 users with units 10½ to 15½ cu ft report an average of $1.65 per month, 14 with units of 17 to 17½ cu ft reported an average of $1.56, and 11 with units 20-29 cu ft showed an average of $1.89. The lowest cost per month reported was 50c, and only 12 users reported a cost of $2.50 or more per month. Many of the costs furnished are probably estimates.

Conclusions. The only apparent basis for choosing the size of frozen food unit to be purchased seems to be the price and an accessible location for the unit. There is no apparent relation between number in the family and capacity of unit, nor between the distance from town or from a community frozen food locker plant and the size of the unit purchased.

The first tabulation shows that many of the owners would buy larger units if they were to buy again.

The frozen food unit is more popular for preserving meats than for preserving fruits and vegetables.

Only a few owners take advantage of the service offered by the community frozen food locker plant.

The basement seems to offer the most desirable location for the unit, but some owners report that it was necessary to buy a unit smaller than needed in order to get it into the basement.

Some users are freezing such large amounts of meat at a time that it requires 36 to 48 hr to complete the process.

The various opinions expressed regarding quality of frozen products indicate that some users either are not choosing varieties best suited for freezing or are not properly preparing them for freezing and storage.

This report was presented at the annual meeting of the American Society of Agricultural Engineers at Lafayette, Ind., June, 1943, as a contribution of the Rural Electric Division.

D. EMERSON WIANT is associate professor of agricultural engineering, Michigan State College.

Frozen food units for the home seem to be comparatively free from mechanical troubles.

Future Considerations. Prospective owners should give serious consideration to capacity needed before purchasing a unit. The average freezing and storage capacity for the nine families who freeze 100 per cent of their meat, fruits, and vegetables is 2.78 cu ft. Indications are that owners will freeze a greater variety of products each succeeding year; therefore, 2.78 cu ft per person is insufficient. (Approximately 5 cu ft per person is required to freeze and store the amounts recommended as an adequate diet for active people by the U. S. Bureau of Home Economics.)

Owners and prospective owners should determine whether their local community frozen food locker plant services can be used advantageously.

The manufacturer should encourage the owner to utilize his frozen food unit to the best advantage. This can be done by stressing the wide range of foods that can be frozen and the importance of proper selection and preparation of products.

The need of a cooling room and the desirability of a separate freezing chamber are problems that deserve consideration but they are not determinant.

Should we encourage the farmer to build his own frozen food unit? Should the fear that a vapor-proof job cannot be done satisfactorily by the one building his own unit keep him from building it, or should we prepare plans which provide for the removal of insulation in order to dry it after a few years of use?

Can we devise a "drop-in" type of mechanical unit? Can we devise connections which will enable the builder on the farm to connect the evaporator to the compressor?

The enthusiasm of the users of frozen food units, the interest of the farm service advisors, the utilities, and the REA cooperatives indicate a big demand for frozen food units in Michigan.

Farm Terracer vs. Moldboard Plow

TO THE EDITOR:

THE implementing of farm terracing in the last three decades comprises a large range of tools — from the moldboard plow (sometimes assisted by spade and shovel) to the large power outfits. This has raised some important questions of efficiency of the farmer's tools in relation to the standards of well-engineered terracing of today.

Farmers themselves may be said to have discovered the need of improvement in the moldboard plow in the early years of the century. A pioneer manufacturer of terracing equipment told me that his first output of implements was as ditchers. Soon he began to receive inquiries from farmers as to the adaptability of these ditchers to building terraces. A thorough investigation of the need was made, many tests were run in various parts of the country, and the small ditcher-terracer-grader was developed, which could be drawn by horses, mules, or farm tractor, and easily handled by the farmer and his help for terracing.

Soil conservation in the Americas at that time was in its infancy. The demand for terracing came only from the most progressive farmers. Education and promotion of terracing to save our runaway soil was done almost entirely by manufacturers of these small terracing tools, which the farmers could own at no greater cost than other farm implements. Yet so successful was the enterprise that several manufacturing concerns began to build these special tools. Their terracing machinery business grew and prospered. It withstood the sudden advent of the big power outfits with the national soil conservation movement in the early thirties. It is in operation today (under the restrictions imposed by war work) and is planning for expansion in the time to follow victory.

Thus the burden of proof of the special qualifications of the individual farm-owned terracer swings from one extreme to the other — first to the moldboard plow, then to the big power outfit, now back again to the moldboard plow.

Considerable material in support of the moldboard plow has appeared in AGRICULTURAL ENGINEERING in the last year, notably the papers, entitled "Building and Maintaining Terraces with Ordinary Farm Machinery" (October, 1943) and "Building Terraces with the Moldboard Plow" (January, 1944).

In certain relatively loose soils, passable terraces can be built with the moldboard plow; in fact, they have been built with the old walking type of plow. The moldboard plow can be used more or less in the sandy soils, especially in the Southeast where as yet the majority of farmers do not have sufficient power to pull heavier equipment. But in other sections, for example, in heavy black land, with plenty of power available a terracing tool with blade formed for the work will always be in demand.

An agricultural engineer, who owns farms in the black land section of Texas and who had been terracing his fields with poor to fair success with the means at hand — road graders, moldboard plows, etc.—wrote me as follows: "About three years ago we reconstructed our entire terracing system using terracing tools especially designed for operation with tractor power. Since then our terraces have withstood the most severe tests from heavy rains without a break. Our records of cotton yields made on terraced and unterraced land show that our later terracing is paying handsome dividends. Now that we have our fields in such satisfactory condition for preventing tremendous amounts of runoff, it may be said that our experience with tractor-powered terracing tools is a complete success."

In the years preceding our entry into the war, we received many reports of the work done by these terracers under agricultural engineering supervision. They not only show terraces constructed to the most critical standards, but at a saving of time, labor and other costs over any other tools — more than half in many instances. Also, it has been many times asserted, and so far as I know, never disputed, that especially designed farm-powered terracers have built more miles of terraces than all other tools combined.

Today's terracing requires a terracing tool, one with the weight, balance, and design and pitch of blade that will construct terraces up to engineering standards most speedily and at the lowest cost. An A.S.A.E. subcommittee in 1937 made a report on terrace equipment construction which considered terracer blade construction, adaptability to wide range of soil conditions, freedom from mechanical failure, etc., etc. Big power outfits on through the various types of terracers drawn by farm tractors or animal power — everything known to be used for farm terracing at the time, except the moldboard plow, is considered in the report.

The importance of the terracer blade is indicated in this report by the fact that it receives more attention than any other feature of the terracer. Width, length, curvature, leverage for raising and lowering, are all emphasized. Apparently it never entered the minds of the subcommittee that anything but special construction for the specialized job of terracing should be considered.

Why then encourage the farmer to go back to the moldboard plow? The successful farmer realizes the advantage of providing himself with a tool for each particular job. The tractor-powered terracer — efficient also for ditching and grading — is one of them.

GEO. H. DAUGHERTY

Sales promotion representative
Owenboro Ditcher and Grader Co.

A tractor-powered ditcher-terracer-grader in action

Peter, You Can Never Be President . . .

But, that's about the *only* door that's barred to you —an immigrant boy—in America.

You can become a great doctor. Or a painter or musician. You can be the head of a business. You can be a farmer, a teacher, a scientist, a mechanic, a clergyman or a statesman.

The opportunity is *here.*

The fact that you are poor—and were born in a foreign country needn't hold you back. In this country nearly everyone at the top started at the bottom.

Whether you work for somebody else—or employ other people in a business of your own—*you're free in America.*

And that is important.

It's that very freedom for individuals, industry and agriculture that provides incentive, creates competition, permits business to grow, makes jobs, increases production, lowers costs and raises wages.

That's the American way.

In this country we have always encouraged inventive skill and ingenuity. We take pride in honest work and achievement.

The highest standard of living in the world is the result.

But in spite of all that, you'll find people here who talk about "rebuilding America." They would like to change all the things that have made America great —and pattern it after some other country.

You'll hear a lot about voting for so-and-so because he'll "take care of you and your family from now on."

But you'll find that most self-respecting Americans *prefer to take care of themselves*—and work out their own futures.

Americans don't like to be pushed around.

Our forefathers founded this country to get away from that sort of thing.

That's why millions of people have settled here—and prospered. That's why you and your parents came over here.

Study this country carefully, Peter. Find out what really makes it tick.

Discover for yourself how the power and the glory of America lie in her birthright of freedom and opportunity.

Remember that we are fighting this war to defend that birthright.

No, you can never be president, Peter—but your children can! And *you* can win a solid place for yourself and build a shining future here, *if* you will learn to stand on your own feet and *if* you will do your share to keep America American.

BUY WAR BONDS AND STAMPS —AND KEEP THEM!

The Army-Navy E flag waves over 7 Republic plants and the MaritimeM floats over the Cleveland District plant.

REPUBLIC STEEL

GENERAL OFFICES: CLEVELAND 1, OHIO

Export Department: Chrysler Building, New York 17, New York

WOVEN WIRE FENCING • BARBED WIRE • STEEL FENCE POSTS • BALE TIES
ROOFING and SIDING • NAILS • STAPLES • BOLTS, NUTS and RIVETS • PIPE
CARBON, ALLOY and STAINLESS STEELS for FARM and DAIRY EQUIPMENT

Progress of Hydrologic and Hydraulic Studies

By C. E. Ramser

FELLOW A.S.A.E.

PRACTICALLY all soil conservation practices on the farm are for their greatest effectiveness fundamentally dependent upon hydrologic and hydraulic research which deals with water from the time it reaches the ground as precipitation until it arrives at the field waterways and stream channels. Soil conservation practices are planned in accordance with the best results of research so that crops are effectively and economically supplied with moisture needed for normal development and to carry them through possible drought periods, so that the maximum amount of rainfall is withheld in the soil to prevent damaging floods, and so that excess water that cannot be stored in the soil is conducted from the farmer's field without causing serious gullying and injurious soil erosion.

The field studies of the Soil Conservation Service, U. S. Department of Agriculture, are divided into three separate parts as follows: (1) The determination by actual measurement of runoff, precipitation, and other factors, of the effect of farm conservation practices on erosion, runoff, and floods, (2) obtaining by field measurement information on runoff from agricultural areas required in the design of various soil and water conservation structures and practices on farms, and (3) developing, by means of outdoor and indoor hydraulic laboratory tests, economical and safe methods of the disposal of excess water from agricultural lands with a minimum amount of erosion. The need for the foregoing information may be set forth as follows:

1 Information on the influence of farm-land practices on the runoff and erosion from complete natural watersheds is needed in the planning of watershed improvement programs directed toward the conservation of the soil, the reduction of floods, better use of water resources, and the attainment of a balanced agricultural economy. Emphasis is made in these studies upon methods of conserving water for crops such as contouring, terracing, and surface mulching which will furnish the basis for a forward-looking land use program particularly for the Great Plains drought area.

2 The hydrologic data being collected especially for use in the economic design of erosion control and hydraulic structures will make possible dependable estimates of the magnitude of runoff which must be handled by terraces, terrace outlet channels, spillways, check dams, culverts, and other hydraulic works used in the soil and water conservation program on the farms. A lack of dependable information on runoff often results in the failure of such works. Perhaps even more frequently insufficient information leads to the use of unnecessarily high factors of safety in the design of these structures and thus to unjustifiably high costs.

OBJECTIVE IS TO INCREASE EFFICIENCY AND DEPENDABILITY

3 The major objective of the hydraulic field and indoor laboratory investigations is to increase the efficiency and dependability and at the same time when possible to reduce the cost of terrace systems, soil saving dams, farm ditches, road culverts, spillways, check dams, and other farm structures required in conjunction with the agronomic and other soil conservation practices in the enlarged food production program of the Soil Conservation Service. Tests are made to determine the discharge capacity of channels, spillways, and related structures and practical methods are developed for protecting channels from scour by means of grasses and other inexpensive linings.

Hydrologic Land Use Studies. Studies of the hydrologic importance of mulch on watershed behavior have been continued at the stations at Hastings, Nebraska; Lafayette, Indiana; College Park, Maryland; Cherokee, Oklahoma; East Lansing, Michigan, and Coshocton, Ohio. Advance data from the central Great Plains experimental watershed near Hastings, Nebraska, show that mulching and subsurface tillage have promise of value in decreasing runoff and erosion, especially during periods when the soil is ordinarily unprotected. Tests at Coshocton, Ohio, indicate that these practices may have considerable influence on the farming practices of that section of the United States. Indiana tests show that straw mulch applied to wheat immediately after seeding in the fall appears to have protected the wheat from winter kill and also to have decomposed and provided nutriments to the wheat at the required time.

From the subsurface tillage experiments on watersheds near Hastings, Nebraska, it was found that in a rotation where wheat follows oats, the practice of subtilling for oats instead of the usual farming practice will increase the amount of available moisture for winter wheat. As much as 3 in of water was gained in the first 6 ft of soil by preparing the oats ground by subtilling. Since many experimenters have found that the yield of wheat is greatly dependent on the available soil moisture at planting time, the practice of subtilling may be expected to increase wheat yields in this region.

At the Indiana Agricultural Experiment Station at Lafayette it was discovered that contouring of corn on small watersheds with average slopes of 2 to 3 per cent resulted in 47 per cent less runoff during the growing season than occurred on similar watersheds with the corn checkrowed. Measurements made in August showed 50 per cent more moisture available for crops in the upper 14 in of soil on the contoured corn than on the checkrowed corn. Moisture deficiency frequently limits the corn crop in this locality and it can be concluded that contouring of corn even on relatively gentle slopes materially reduces an important production hazard. Mulching of wheat with 2 tons per acre of wheat straw immediately after drilling resulted in saving the crop from practical failure, the yield being 19.5 bu per acre on mulched plots as compared to 5.5 bu per acre on the check plots. It was found that mulching improved the soil structure by increasing the percentage of large pore space and resulted in increased infiltration and higher moisture content, particularly near the surface. A mimeographed publication entitled "A Brief Report of Results Bearing on Increased Agricultural Production for War Needs" was prepared during the year by the Indiana Agricultural Experiment Station in cooperation with the U. S. Soil Conservation Service.

TO LEARN RATE OF THAWING FROZEN SOIL

One of the major activities at the Michigan Agricultural Experiment Station at East Lansing, Michigan, consisted of preparing material for the weather directorate of the Army Air Forces, Washington, D. C. The directorate is interested in analyzing these data in order to learn of the rate of thawing of frozen soil. Such information is of fundamental importance in the operation of unpaved emergency airfields in the north country. It is known that the impact of landing wheels on heavy aircraft often amounts to many tons per wheel. Since a freshly thawed-out soil is apt to be water laden beyond its soil capacity and, because of freezing and thawing processes, in a structureless condition, attempts to use unpaved landing fields immediately after thawing of the surface layers of the soil may entail tremendous risk.

A report covering total runoff, peak flows and erosional materials in runoff water from the watersheds of the Navajo Conservation Experiment Station at Mexican Springs, New Mexico, was released for use especially in the design of livestock ponds needed in the increased meat production program of the Soil Conservation Service on range lands. Heretofore little or no data have been collected for that area by any agency, so these data will prove invaluable for designing and constructing soil conservation structures. Also, upon request our hydrologic data from the Navajo station were furnished the U. S. Department of the Interior for its range studies.

The publication of five hydrologic bulletins in the new departmental series has established a permanent record of basic hydrologic data useful to the various action programs of the Department of Agriculture; to the War Department in dealing with runoff problems in army camps, airports, and operations on power and navigation projects; to the Public Roads Administration and state highway departments for use in designing *(Continued on page 188)*

Report presented at the fall meeting of the American Society of Agricultural Engineers at Chicago, December, 1943. A contribution of the Soil and Water Division.

C. E. RAMSER is research specialist in hydrology, Soil Conservation Service, U. S. Department of Agriculture.

Hydrologic and Hydraulic Studies

(Continued from page 186)

culverts, weirs, check dams, and diversion ditches; and to municipal engineers, railroads, utilities, and others in their water supply and water control problems.

The hydrologic studies, besides serving the needs of the Soil Conservation Service, have furnished valuable by-products for the war program. Ground-water and runoff figures are being made available to power companies engaged in supplying hydroelectric power to vital war industries. Our data on frost, soil temperature, and moisture in a northern state are being studied by highway transportation officials for the purpose of determining highway safe loads and routing of commercial and military truck traffic. Hydrologic data from our various field research stations were furnished, prior to publication, to the U. S. Army, Public Roads Administration, the U. S. Weather Bureau, the U. S. Geological Survey, contractors, consulting engineers, and others for their use in designing flood control projects; tile drainage systems for airports; storm drainage works for army cantonment sites and ordnance works and highways; and waterways for bridges and culverts.

Runoff Studies. Summaries of the data collected on runoff studies have been furnished Soil Conservation Service engineers and farm planners and have proved of great assistance in the design of conservation structures and practices. These data have been furnished the War Department for use in dealing with runoff and drainage problems in army camps, airports, and in the operation of power and navigation projects; the Public Roads Administration and state highway departments for use in designing culverts, weirs, check dams, and diversion ditches for erosion control along highways; and contractors, consulting engineers, and officials of railroads and municipal utilities, and other organizations for use in their water supply and water control problems.

RESEARCH STUDIES AT THE HYDRAULIC LABORATORIES

Material for two bulletins was prepared at the Virginia Agricultural Experiment Station at Blacksburg. The title of one of these proposed bulletins is "Runoff from Small Agricultural Areas in the Limestone Valley Section of Virginia" which summarizes the results of runoff studies conducted in cooperation with the Soil Conservation Service since the beginning of this work. The other relates to the building and management of farm fish ponds which was considered by the state as contributing an essential part to the food production program. Results of runoff studies were used in recommendations for the hydraulic design of fish ponds.

Hydraulic Studies. In order that the hydraulic research work at the St. Anthony Falls hydraulic laboratory at Minneapolis, Minnesota, might have the most immediate value in relation to the war effort, most of the emphasis during the year was placed upon improvements to existing unsatisfactory soil conservation structures and upon the development of economical and satisfactory devices to be used with new structures to dissipate the energy of flowing water and thereby eliminate or reduce greatly the scour in the downstream channels. The results of the research activities have provided information which will aid the field technicians of the Soil Conservation Service in designing more economical and safer engineering structures. Tests have been made of concrete flumes, rectangular spillways, and vitrified tile pipes to determine their water-carrying capacity so that their size can be properly planned to carry off the excess runoff water from a given area. A satisfactory design of an outlet for use with high velocity flows such as exist in long steep flumes and drop inlet culverts has been achieved. The design of an outlet to be used with various types of rectangular spillways which handle relatively large depths of flow at lower velocities is practically completed. Investigations assume added significance at the present time since farmers must conserve both materials and labor yet at the same time provide structures which have adequate capacity for handling the runoff water.

A new and improved structure was developed in the hydraulic laboratory at Pasadena, California, for stilling high velocity pipe flow so that it can be discharged into a natural earth channel without causing appreciable erosion. The structure is very simple, small, and cheap to construct. It can be made of concrete, masonry, or wood, and can be used at the ends of pipes used with drop-inlet culverts or that carry irrigation waste water from fields into natural drainage channels in connection with the field program of the Soil Conservation Service.

An important accomplishment during the year was an analysis of the vegetal channel data at the outdoor hydraulic laboratory that was located near Spartanburg, South Carolina, and the preparation of this material for publication as a bulletin. This proposed bulletin will contain permissible velocities for field waterways and terrace outlet channels for kudzu, lespedeza, sudan, centipede grass, Dallis grass, and grass mixtures for green, dead, and dormant conditions. Also the value of the retardance coefficient in Manning's formula was determined for each of these grasses which will make it possible in the field program to design conservation channels with adequate capacity to provide for the runoff from the tributary areas.

Hydraulic work in the outdoor laboratory at McCredie, Mo., has consisted of the actual testing of one vegetated channel containing four sections seeded to different grass mixtures, namely, red top and timothy, Canada bluegrass, Kentucky bluegrass, and Brome grass to determine their water-carrying capacity and their effectiveness in preventing erosion in farm waterways.

Requests have been received for the results of the foregoing hydraulic laboratory investigations and information has been furnished the Public Roads Administration for use in design of road culverts and channels and in controlling erosion in roadside ditches.

A bulletin entitled "Tests on Vegetated Waterways" was published during the year by the Oklahoma Agricultural Experiment Station in cooperation with the Soil Conservation Service. It contains tests of channels lined with different grasses — blue grama, Buffalo, Bermuda, and weeping love grasses — to determine their resistance to erosion in terms of velocity of flowing water and their retardance to flow as measured by the amount of water discharged in a given time. This information is especially needed to conserve the soil in the intensive drive for increased food production.

In connection with the food production program of the Department of Agriculture the hydraulic work at Logan, Utah, has been confined mainly to the important problem of preventing seepage in the lining of canals which will result in increased food production through the conservation of the water supply available for irrigation. The first phase of this study will involve measurements to determine the extent and locations of seepage losses. Plans have been made and work is in progress to obtain measurements on a number of representative canals in seven or eight counties in the state. Other studies made at Logan to determine the influence of the size of the irrigation stream and the slope of the furrow on erosion indicate that very large soil losses occur with the application of irrigation water even where the slopes are gentle and reasonably good irrigation practices follow. It was found that infiltration decreased with the slope of the furrow. The measurements were made in furrows on land devoid of vegetation and therefore the results apply only to intertilled crops. There is need for further careful study to develop methods of irrigation practice which will be unaccompanied by excessive erosion and which will utilize the water supply more effectively.

Education of the Engineer

THE education of the engineer begins in the home and continues throughout his life. During the early stages of his education he forms habits of study and methods of approach which determine whether he will be an ignorant handbook technician who wishes he had studied certain subjects in college. . . . .

A few things are self-evident. The student must certainly learn the language of the profession, he must learn its basic sciences, he should learn the laboratory method, the research approach, and he should learn enough technology to become acquainted with the method attitude and spirit of the profession. In addition, he should learn its code of ethics and the peculiar techniques of its practitioners.

Certainly the engineer must be a citizen of the community, state, and nation in which he lives. He must learn, either in college or elsewhere, enough history, psychology and civics to be a good citizen. Introduction to these fields, during his college course, will help him read with discrimination the vast literature in economics, government, and human relations. A few basic courses, under wise teachers, may start him on the way to good and active citizenship rather than leave him as an easy mark for crackpot reformers and milk bottle philosophers.

— N. W. Daugherty in S.P.E.E. "Journal" for March 1944.


JOHN
RE
... and Buy It with Confidence!

NEWS SECTION

The 1944 A.S.A.E. Annual Meeting Program

THE 37th annual meeting of the American Society of Agricultural Engineers, to be held at the Hotel Schroeder in Milwaukee, Wisconsin, June 19 to 21, will feature a program of exceptional and timely interest, not only to members of the Society but also to others concerned with the subjects to be presented.

During the first period of the meeting, Monday forenoon, June 19, three concurrent programs will be presented, namely, farm structures, power and machinery, and soil and water.

The farm structures program is sponsored by the Society's Committee on Hay Harvesting and Storage and will include a paper on barn curing of hay with heated air by John Strait, University of Minnesota, with a discussion by C. E. Seitz, Virginia Polytechnic Institute; a paper on nutritional values of hay and silage as affected by processing and storage, by Dr. G. Bohstedt, professor of animal husbandry, University of Wisconsin, and a paper on new developments in hay storage structures by S. A. Witzel, University of Wisconsin.

The power and machinery program will include two papers on weed control, one on the flame control method by Harold T. Barr, Louisiana Agricultural Experiment Station, and the other by the use of chemicals, by John F. Benham, agricultural agent, Pennsylvania Railroad Co. An address by Joe Tucker, general sales manager, Massey-Harris Co., on trends in self-propelled farm machines will be the third feature of the program of this session.

The soil and water program for the same period opens with a paper on a 100 per cent county terracing program by C. V. Phagan, Clemson Agricultural College, followed by two papers on irrigation — one dealing with new methods of land preparation for irrigation by W. O. Wallinder, Farm Security Administration, and another on soil and water conservation in irrigated areas by Frank Kimball, Soil Conservation Service.

The first general session of the meeting is scheduled for the second period of Monday afternoon, June 19, and will be opened by Frank J. Zink, chairman of the 1943-44 Meetings Committee. Three addresses are scheduled for this session, the first of which will be the president's annual address by Arthur W. Turner, educational adviser, International Harvester Co., and 1943-44 A.S.A.E. president. This will be followed by an address by Deane G. Carter, University of Illinois, on some concepts in the relation of farm structures to agriculture, and one by G. B. Gunlogson, Western Advertising Agency, on new concepts in the relation of farm machinery to agriculture.

The third period of the meeting, Tuesday forenoon, June 20, will be devoted to four concurrent programs under the main headings of farm structures, rural electrification, power and machinery, and soil and water.

The first two papers of the farm structures program will deal with problems of drying and storage of rice. Kyle Engler and Xzin McNeal, University of Arkansas, will discuss the artificial drying of combined rice, and Harold A. Kramer, Louisiana Agricultural Experiment Station, will discuss the design and construction of bulk storage bins for rough rice. In addition Hugh C. Smith, Sisalkraft Co., will present a paper on temporary and portable silos, and Keith H. Hinchcliff, Mississippi State College, will discuss his cooperative extension activities with farm building materials dealers.

The power and machinery program will open with a paper on what engineers are doing to control the European corn borer by R. H. Wileman, Purdue University Agricultural Experiment Station, which will be followed by a report by W. J. Coultas, chairman, Advisory Engineering Committee, on the activity of engineers of the farm equipment industry in converting tractor and implement hookups to A.S.A.E. standards. It is hoped to present also at this session the subject of styling of farm machines, to be handled by a competent authority on the subject.

The soil and water program for this period will feature the subject of drainage in three papers. The first deals with farm drainage in the future and will be presented by P. W. Manson, University of Minnesota. John G. Sutton, U. S. Soil Conservation Service, will present a technical paper on the hydraulics of open drainage ditch design, and Fred F. Shafer, also of the SCS, will discuss the functions of soil conservation districts in drainage work.

The fourth period of the meeting, Tuesday afternoon, June 20, will be given over to the second general session of the meeting. The program will consist of a symposium on the subject "Rural Industry—a Challenge for Agricultural Engineers." Principal speakers on this program will be True D. Morse, president, Doane Agricultural Service, and Clarence J. Hurd, chief, agricultural engineering development division, Tennessee Valley Authority.

The fifth period of the meeting, Wednesday forenoon, June 21, will feature three concurrent programs, namely, a joint structures and machinery program and separate rural electric and soil and water programs.

The structures-machinery program will open with an address by Frank J. Reynolds, Carnegie-Illinois Steel Corp., on the effect of farm mechanization on farm structures. This will be followed by an address by H. G. Ingerson, John Bean Mfg. Co., on a new method of farm fire protection which will feature the high-pressure fog development of that company for fighting fire. Also George Amundson, Michigan State College extension agricultural engineer will discuss the use of farm sprayers as fire protection units.

Two papers will be presented on the rural electric program, one on an electro-economy for agriculture by D. W. Teare, Rural Electrification Administration, and the other on new techniques in milking by Dr. Geo. H. Hopson, The DeLaval Separator Co. Another feature of this session will be a colored motion picture on farm life in Northern Illinois to be presented by D. L. Womeldorff, Public Service Co. of Northern Illinois.

The soil and water program for this period will consist of three papers on farm ponds. J. L. McKitrick, University of Kentucky, will discuss current problems in farm pond construction; L. L. Harrold, U. S. Soil Conservation Service, will present a paper on planning farm ponds to insure ample water supply, and John R. Carreker, also of the SCS, will discuss the construction and management of farm ponds for various purposes.

Four concurrent programs are scheduled for the sixth period of the meeting, Wednesday afternoon, June 21, under the main headings of farm structures, rural electric, power and machinery, and soil and water.

The farm structures program will open with a paper on gypsum board in farm building construction by H. J. Schweim, Gypsum Association, followed by a paper on the applications of new developments in timber construction to farm buildings by L. P. Keith, National Lumber Manufacturers Association. Wallace Ashby, in charge of farm structures research (BPISAE), U. S. Department of Agriculture, will report on a survey in the field of farm structures which he is completing.

The rural electric program for this period will include two talks on the relation of engineering to problems of manufacture and distribution of farm electric equipment, one by C. V. Holman, International Harvester Co., and the other by a representative of the General Electric Co. These will be followed by a talk on the challenge of farm electrification by Frank E. Watts, Farm Journal, Inc.

The power and machinery program will open with a paper on deep placement of fertilizers by Dr. G. D. Scarseth, chief in agronomy, Purdue University Agricultural Experiment Station. This paper will be followed by one on recent engineering developments in fertilizer placement by G. A. Cumings, U. S. Bureau of Plant Industry, Soils and Agricultural Engineering, and chairman of the National Committee on Fertilizer Application. A third paper on checkrow planting at higher speeds will be presented by A. C. Sandmark, Deere & Mansur Works of Deere & Co. Harold V. Hansen, Harry Ferguson, Inc., will follow with a discussion of the time and labor saved by the higher speed drill planter.

The soil and water program will open with the showing of still and motion pictures of the phenomena of erosion by raindrop splash made in connection with the raindrop erosion studies at the Coshocton, Ohio, project of the Soil Conservation Service and reported by W. D. Ellison in AGRICULTURAL ENGINEERING for April and May, 1944. This will be followed by a paper by Fred W. Blaisdell, St. Anthony Falls Hydraulic Laboratory of the U. S. Soil Conservation Service, on new developments in the design of erosion control structures, which will be followed by a visit to the Milwaukee office of the SCS for a demonstration of models of structures designed for controlling erosion in gullies and for the outlet end of culverts and chutes. *(Continued on page 192)*

A.S.A.E. Meetings Calendar

June 19 to 21 — Annual Meeting, Hotel Schroeder, Milwaukee, Wis.

December 11 to 13 — Fall Meeting, Stevens Hotel, Chicago.

NEWS SECTION

(Continued from page 190)

The annual dinner, the climatic event of A.S.A.E. annual meetings, will be held the evening of Wednesday, June 21, on which occasion will be awarded the 1944 John Deere and Cyrus Hall McCormick gold medals.

The College Division of the Society is arranging and will present a program of special and timely interest to the college group of A.S.A.E. members on Thursday, June 22.

Thomas Jefferson Celebration

By F. A. Wirt

ON THE 201st birthday of Thomas Jefferson, Thursday, April 13, it was my privilege, as representative of the American Society of Agricultural Engineers on the National Agricultural Jefferson Bicentenary Committee, to be one of a large group making a pilgrimage from Washington to Monticello.

Arriving in Charlottesville, we were driven to the University of Virginia where we saw buildings designed by Thomas Jefferson and constructed under his supervision. In our inspection trip over the campus, we saw the famous serpentine brick wall so built that a wall one brick wide possessed stability.

Rooms in which Edgar Allen Poe and Woodrow Wilson slept and studied were called to the attention of the group.

In the rotunda, also designed by Jefferson, there was a radio broadcast on the National Farm and Home Hour. Dr. J. R. Hutcheson, director of the agricultural extension service of the Virginia Polytechnic Institute, paid tribute to the land-grant college, the agricultural experiment station, and the agricultural extension services.

The Honorable Claude R. Wickard, Secretary of Agriculture and chairman of the National Agricultural Jefferson Bicentenary Committee, spoke on Thomas Jefferson, the founder of modern American agriculture.

Prior to the broadcast, Dr. Herbert A. Keller of the McCormick Historical Association of Chicago, spoke on living agricultural museums.

At one o'clock the party was transported by automobile to Monticello where the home of Thomas Jefferson, designed by him, was carefully inspected both inside and out. On the top of the mountain on which Monticello is located we could look off to the Blue Ridge Mountains, and in the other direction 25 to 50 miles of Virginia Piedmont could be seen.

Following an open-air luncheon of fried chicken and all the things that go with it, there was an interesting program on the east step. Professor Edwin M. Betts of the University of Virginia told us of the gardens at Monticello and of the interest taken by Jefferson in their design and supervision.

Professor James E. Ward of Clemson College spoke of the farming activities at Monticello in Jefferson's time, a most interesting discussion of the farming methods of that early day.

Later in the afternoon there were memorial exercises and the laying of wreaths on Jefferson's grave. *(Continued on page 196)*

Bread, Not Stones

(Continued from page 166)

son, son-in-law or expert farmhand, familiar with the farm, trained in farming, and only awaiting the end of the war to return from fighting or factory front. There is no surplus for absorption of additional men, strangers alike to the present farmer, the particular farm, and to farming in general.

The final, fantastic expedient, that of cutting up farms to make more homes, is directly opposite to all the promise which our profession offers to agriculture. We have every respect for the family farm, but it remains true that the major handicap in the mechanization of farms is acreage too small for the efficient use of power and machine units. It is disservice to the farm family to acquiesce, much less to aid, in a program which would only push them back toward peasantry.

Instead of exiling veterans to stumps and stones, we should encourage every measure to make solvent employment, including farm employment. By engineered methods we can make farm labor productive enough, per man-hour, to permit payment of wages more nearly in line with industrial wages, and certainly to provide a better standard of living than can be coaxed from too small a piece of marginal land with primitive implements.

Personals of A.S.A.E. Members

William Aitkenhead, professor emeritus of agricultural engineering and former head of the agricultural engineering department at Purdue University, was specially honored during the Purdue University Agricultural Conference held earlier this year. On that occasion his portrait, painted by Randolph Coats, an Indianapolis artist, was unveiled. The portrait was sponsored by the Purdue Agricultural Alumni Association and friends of Professor Aitkenhead. The unveiling took place in the Agricultural Engineering Building during a fish fry, for which that building is famous and with which A.S.A.E. members attending the Society's 1943 annual meeting are familiar.

Merle W. Bloom has resigned as research engineer, tractor division, Allis-Chalmers Mfg. Co., to engage in farm machinery development work in the farm equipment division of Sears, Roebuck & Co.

C. R. Carlson, Jr., recently received appointment as general manager of Deere & Webber Co., the distributing branch of Deere & Co., at Minneapolis, Minn. Mr. Carlson became associated with Deere & Webber Co. in 1925 in sales and service work. In 1930 he was appointed manager of the John Deere organization at Welland, Ont., and in 1936 was transferred to the John Deere Tractor Co., at Waterloo, Iowa, as assistant manager.

Frank D. Dale has resigned as designing engineer, Harry Ferguson, Inc., to become a partner in the operation of 4500 acres of ranch land at Coldwater, Kans. He will serve as farm manager of the enterprise.

Stanley E. Hill has resigned as field engineer for the John Deere Harvester Works and is now employed as senior engineer in the David Bradley Mfg. Works development department of Sears, Roebuck & Co., in Chicago.

Keith Hinchcliff, assistant extension agricultural engineer, Mississippi State College, has prepared minimum construction recommendations for farm-sized sweet potato *(Continued on page 196)*

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Wesley F. Buchele, Lt., Infantry, U.S.A., 11th Co. 1st STR, Fort Benning, Ga.

Thomas H. Coulter, secretary, Vermiculite Research Institute, 135 S. LaSalle St., Chicago, Ill.

Donald M. Crooks, midwestern representative, Douglas Fir Plywood Assn. (Mail) 1707 Daily News Bldg., Chicago 6, Ill.

Robert A. Crosby, advertising manager, tractor division, Allis-Chalmers Mfg. Co., Milwaukee, Wis. (Mail) 1138 So. 77 st.

Lester V. Kent, building contractor, 205 W. Collins St., Midland, Mich.

Harold A. Kramer, assistant agricultural engineer, Louisiana Agricultural Experiment Station, Baton Rouge, La.

Melvin J. Proud, agricultural sales manager, Allis - Chalmers Mfg. Co. (Mail) 862 Kensington, Memphis 7, Tenn.

H. V. Snow, implement sales manager, Allis-Chalmers Mfg. Co. (Mail) RR No. 2, Eagle, Wis.

S. H. Sorensen, harvester sales manager, Allis-Chalmers Mfg. Co., Milwaukee, Wis. (Mail) 2530 No. 71st St.

Murrel E. Strickler, design and drafting, John Deere Harvester Works, East Moline, Ill. (Mail) 2343 6th St. Court.

J. M. Winram, manager, Westminster Farm Equipment Ltd. (Mail) 4561 Marguerite Ave., Vancouver, B. C., Canada.

TRANSFER OF GRADE

Henry H. DeLong, associate professor of agricultural engineering, South Dakota State College, Brookings, S. D. (Mail) 421 12 Ave. (Associate to Member)

J. C. Hundley, Lt. (jg), USNR. (Mail) Tyner, Tenn. (Junior Member to Member)

Donald E. Kuska, engineer, Curtiss-Wright Corporation, Airplane Div., Columbus, Ohio. (Mail) 775 Kenwick Road. (Junior Member to Member)

Reuben O. Schlegelmilch, radio engineer and section chief, U.S.A.S.C., Liaison Office, Research Enterprises, Ltd. (Mail) 45 Lorindale Ave., Apt. 105, Toronto, Ontario, Canada. (Junior Member to Member)

Personals of A.S.A.E. Members

(Continued from page 194)

curing houses and Mississippi farm houses, the purpose of which is to make more result demonstrations possible by recognizing and marking those structures that meet the minimum requirements.

A. Clark Hudson, who until recently was architectural designer at the Holston Ordnance Works, now holds a similar position with Skidmore, Owings, and Merrill, architects and engineers, Oak Ridge, Tenn. He is engaged in the design of community structures for workers at a large war plant.

Harry Miller is now employed as research engineer of the chemurgy project at the University of Nebraska, and is engaged in research in chemical and agricultural engineering as applied to chemurgic problems. More recently he was head of the research department of the Doane Agricultural Service and was stationed at Columbia, Missouri.

John E. Nicholas, professor of agricultural engineering, is co-author of two bulletins issued recently by Pennsylvania State College as follows: Bulletin 461, entitled "The Influence of Light on Age at Sexual Maturity and Ovulation Rate of Pullets," and Bulletin 462, entitled "Light Intensity as a Factor in the Artificial Illumination of Pullets."

Thomas Jefferson Celebration

(Continued from page 192)

It was noted that Thomas Jefferson passed away on the 50th or golden anniversary of the signing of the Declaration of Independence.

Late in the afternoon most of the group visited the farms at Shadwell where Jefferson was born. Here Dr. Hugh H. Bennett, chief of the Soil Conservation Service, pointed out soil conservation practices past and present.

Throughout the day the surroundings and addresses brought out as never before, as far as the writer is concerned, the part played by Thomas Jefferson as a farmer, gardener, soil conservationist, and agricultural engineer, as well as writer and signer of the Declaration of Independence, ambassador to France, and third President of the United States. It would be well for America to know more about Thomas Jefferson's great contribution to education and agriculture. While he spent many, many years in the service of his country and away from home, his thoughts always went back to Monticello, its gardens and farming operations.

How to Dry Combined Oats

To the Editor:

FOR a number of years we have been growing a large acreage of oats in the rice area of Arkansas, most of which have been cut with binders, shocked, and threshed with threshing machines. In recent years some farmers have begun to combine their oats, but we are experiencing some difficulty in keeping them after they have been combined. Those farmers who let their oats get dead ripe and fall over before combining have little trouble from the standpoint of moisture content of the oats, but do have difficulty with combining because of the green vegetation which grows quite rapidly in late May and early June, the period during which our oat crop is harvested. Then, too, some loss from shattering is experienced under these conditions.

Within the next few years there will be a large number of rice driers built in this area, and I am quite sure these driers can be used successfully for drying oats, soybeans or any other grain crop. I would like to get in touch with anyone who has had experience in combining oats and putting them through an artificial drier. I am interested in such questions as (1) have any oats been combined with a moisture content of around 18 to 20 per cent, (2) was any difficulty experienced in getting the oats to thresh off the panicles at a high moisture content (about the stage of maturity at which they would normally be cut with a binder), (3) has any work been done, and by whom, on artificially drying oats, and (4) at what air temperature were they dried?

I would appreciate any information that may be obtainable on these questions.

L. C. Carter

Assistant director in charge,
Rice Branch Experiment Station, Stuttgart, Ark.

PROFESSIONAL DIRECTORY

Consulting Engineering Work In Farm Structures Field
Also Sales Engineering for Selected Manufacturers

GEORGE R. SHIER, A. E.

Member A.S.A.E. Associated with Howard S. Sterner Company, Consulting Structural Engineers, 30 East Broad Street, Columbus, Ohio

Consulting Agricultural Engineer & Farm Market Analyst

FRANK J. ZINK, A. E.

Member A.S.A.E. Suite 4300, Board of Trade Bldg.,
Telephone: Wabash 1558 141 W. Jackson Blvd., Chicago 4, Ill.

RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

AGRICULTURAL ENGINEERS, preferably with some extension experience in farm structures, wanted by a nationally known manufacturer of building materials to do educational, research and promotional work for districts in New York, Chicago and New Orleans. Excellent opportunity for permanent postwar connection with a well-established, substantial manufacturing organization. Salary open. State education, experience, draft status and geographical preference in first letter. PO-161

RURAL DEPARTMENT MANAGER wanted for permanent employment with an eastern electric utility. Immediate opening for competent college-trained, agricultural engineer with experience in modern business promotional sales methods. Familiarity with Pennsylvania-German farmer customs desirable. Salary open. Write fully. PO-160

AGRICULTURAL MACHINERY SALES REPRESENTATIVES wanted, by well known track-type tractor company. Agricultural implement selling experience or farm background essential. Must have proven record of selecting and developing new dealers, handling collections, arranging bank facilities, demonstrations, farm and dealers' meetings, etc. Earning power limited only by ability of representative to develop sales potentiality of his territory. PO-159

AGRICULTURAL ENGINEER is wanted by a nationally known building material manufacturer to assist in farm building design and research and for product promotion and educational work in farm field. An outstanding opportunity for a man with ambition, initiative and ideas to establish a sound and attractive future for himself with an excellent firm. Position requires considerable travelling. Write fully in first letter stating salary requirements. PO-158

AGRICULTURAL ENGINEER with irrigation engineering experience in Italy or with experience under comparable conditions in the southern part of United States is wanted by a federal government agency. Applications should not be in draft classification in which they are likely to be called. A highly competent man able to advise local government authorities concerning the relative urgency of various engineering projects is wanted. Write giving full particulars in first letter. PO-157

EXTENSION AGRICULTURAL ENGINEERS. There are two vacancies on the agricultural engineering extension staff of one of the leading state colleges of the Middle West. Extension projects are conducted in farm equipment, farm structures, soil and water conservation, and rural electrification, but it is desired to have one staff member specialize in farm equipment and the other in drainage. Salaries will depend upon experience. Applicants should submit complete personal records. PO-156

(Continued on page 200)

Here's your receipt for 12,500 gallons of gasoline

Each little rising sun represents a Jap whose sun has set—definitely. It's your receipt for the 12,500 gallons of high octane gasoline it took to train *just one* American fighter pilot.

Makes it easier to see why there's less gasoline available for civilian America, doesn't it? Also why government agencies have had to place limits on the quality of civilian gasoline in spite of improved refinery methods and stepped-up Ethyl production. Remember, practically every gallon of Army and Navy gasoline contains Ethyl fluid.

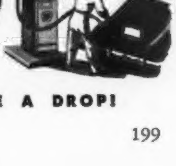
When the fighting is over it's obvious that much of the Ethyl gasoline now going to war will be available for peacetime use.

You'll be able to get gasoline of far higher quality for running your automobile, airplane, truck or bus than you've ever had before . . . and ultimately engines will be designed to get more power and economy from this improved gasoline.

We do not predict any sudden dream world of helicopters and weirdly streamlined automobiles. But we do look forward to cooperating, through our Detroit and San Bernardino research laboratories, with the engineers of the automotive, aviation and petroleum industries in the progress of post-war transportation.

ETHYL CORPORATION

Manufacturer of Ethyl fluid, used by oil companies to improve the antiknock quality of aviation and motor gasoline.



GASOLINE POWERS THE ATTACK—DON'T WASTE A DROP!

EMPLOYMENT BULLETIN

(Continued from page 198)

REGIONAL SERVICE MANAGER seeking postwar security is wanted by well-known, fast-growing manufacturer of farm tractors and implements who is expanding his organization to prepare for postwar opportunity. Man needed to contact distributors to see that factory service policies are inaugurated and followed through. Must be able to command respect; must know farm implements, their use, care and maintenance and be able to pass his knowledge on to others through meetings, training and supervision. Probably college trained with practical experience; married, and between the ages of 30 and 45. Salary open. Write in confidence to Director, Council for Market Development, 1404 Maccabees Bldg., Detroit, Mich.

FARM EQUIPMENT ENGINEERS. National merchandising organization planning large farm equipment program has openings for senior and junior design engineers. Write experience, draft status, salary expected. Replies confidential. PO-155

ENGINEER interested in drainage research wanted. Southern state with large acreage needing drainage plans to begin intensive research program. First letter should give training, experience and references. PO-153

RURAL ELECTRIFICATION SPECIALIST wanted by agricultural college for combination research and extension work. A very progressive southern state with outstanding rural electrification program. Salary commensurate with training, experience and ability. PO-152

AGRICULTURAL ENGINEERING opening in northeastern university. At present the activities will be largely in the extension service with some time devoted to development work in farm equipment and work simplification. Man with general interest or experience in agricultural engineering preferred. Full statement of training, experience, draft status and other information should be given in first letter. PO-150

AD COPY WRITER wanted. Man with some technical experience who is creative and has the knack of writing simple, forceful copy for industrial and technical advertising is desired. Permanent position and good opportunity for advancement with long-established 4-A advertising agency. Correspondence will be kept confidential. PO-146

ENGINEERS WANTED in our plants in CALIFORNIA, FLORIDA, ILLINOIS and other states. Must have had at least three years' experience in general machine design. Our work is postwar development of machines for use in agriculture and in fruit and vegetable canneries, packing houses, and processing plants. Please give full history, including family, also name of state in which you prefer working, and salary expected — also snapshot of yourself if available. Reply to Food Machinery Corp., San Jose, California.

POSITIONS WANTED

AGRICULTURAL ENGINEER with B. S. degree in agricultural engineering from a southern college, with experience in soil conservation; construction; fire-fighting equipment; farm buildings; equipment, and operation — and a farm owner, is available. A disabled second lieutenant of World War II, and has served as instructor in a U. S. Army motor school. Age 28 years; single; draft status, 4-F. Disability will not interfere with agricultural engineering work. Would like position that includes any part of agricultural engineering (preferably in southern states), but will consider any place if salary and living conditions are right. PW-360

AGRICULTURAL ENGINEER (B. S. in horticulture, B. S. in engineering and M. S. in agricultural education) with 25 years of experience in teaching, extension and research directly in the field of agricultural engineering, and at present extension agricultural engineer and department head, wishes a position where his training and experience will have an outlet in developing a full four-year curriculum, postwar rehabilitation courses, vocational-agriculture training courses, or opening new lines of approach in extension or research. Special ability in visual methods of presenting extension material and in the organization of cooperative extension programs. PW-359

AGRICULTURAL ENGINEER with B.S. and M.S. degrees in agricultural engineering and economics, with experience in resident teaching, extension, and research work at two eastern universities, 29 years of age, farm reared, in good health, and whose draft status is 3-D, would be interested in a position teaching agricultural engineering with an opportunity to do research work at some university, or would consider a position with a farm machinery or public utilities company. PW-358